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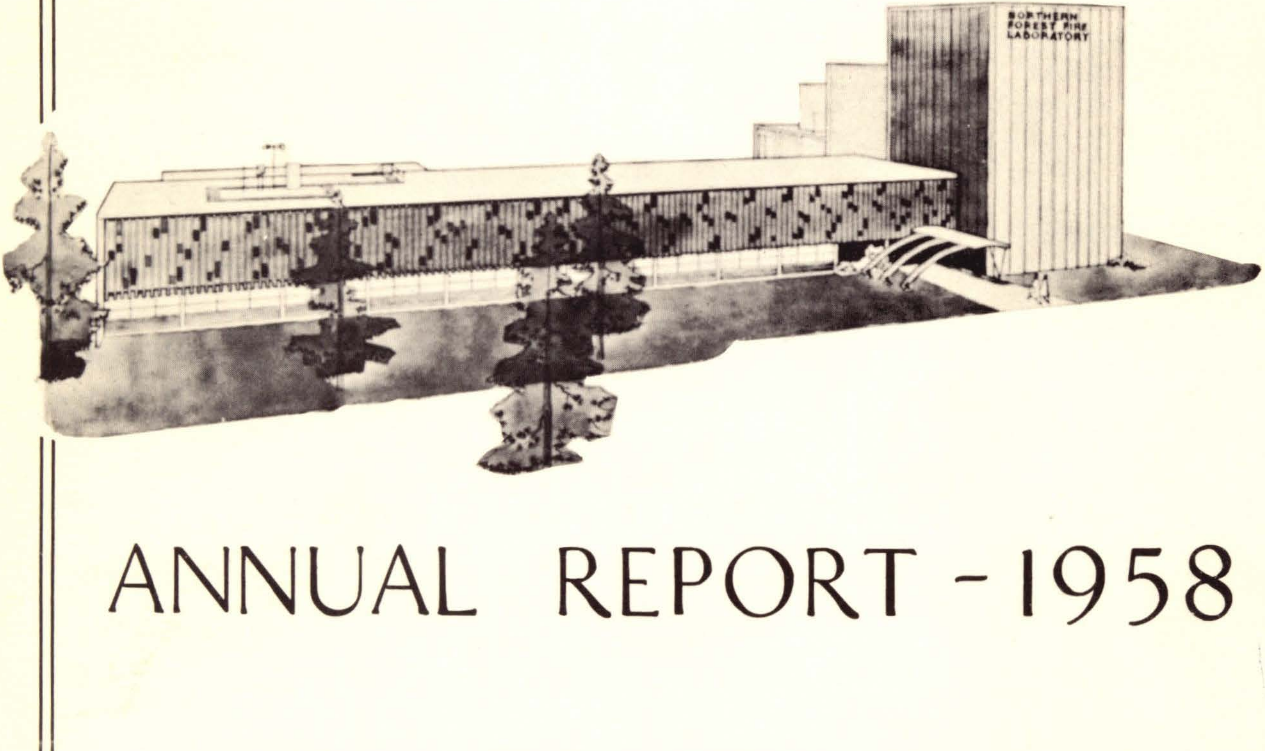
HIGHLIGHTS IN RESEARCH


NORTHERN
FOREST FIRE
LABORATORY

ANNUAL REPORT - 1958

INTERMOUNTAIN FOREST & RANGE EXPERIMENT STATION
FOREST SERVICE
U. S. DEPARTMENT OF AGRICULTURE
OGDEN, UTAH

REED W. BAILEY, DIRECTOR

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(This report covers calendar year activities unless otherwise noted.)

INTRODUCTION

This annual report of activity of the Intermountain Forest and Range Experiment Station departs somewhat from the pattern of earlier editions. In an age of streamlining we feel it appropriate to summarize accomplishments of major significance and to postpone accounts of unfinished projects until they are completed. Details of procedure and results in completed projects may be read in the published reports listed in the Publications section.

Several events of 1958 stand out in sharp relief against the routine of daily work.

Intermountain Station suffered great loss in the tragic death, on March 9, of Dr. Lincoln Ellison, chief of the Division of Range Management Research. Dr. Ellison had been a member of the station staff through two decades. During that time he developed an enviable national and international reputation as a scholar, scientist, and writer. Linc's passing was a loss to the station organization, and the individuals who knew him best felt a deep personal loss also.

The station was pleased to share with Region 4 the opportunity to be host for a brief visit in June from Dr. McArdle, Herr Walter Mann, chief of the German Forest Service, and Herr Wolfgang Koehler of the German Embassy in Washington.

Late in September we were pleased to have an official inspection by Dr. V. L. Harper and George M. Jemison of the Washington Office of Research. A pleasant event of their inspection tour was the official opening of the Northern Idaho Forest Genetics Center on the campus of the University of Idaho.

Another headline event of the year was the 58th annual meeting of the Society of American Foresters in Salt Lake City, attended by nearly 800 professional foresters. Personnel of Intermountain Station and the regional forester's staff shared responsibility for making the numerous necessary arrangements for this meeting and for the operation of a smooth schedule. Several members of the station's staff presented papers on the program. About 275 foresters joined in a guided tour of the Davis County Experimental Watershed.

A red-letter event was the appropriation by Congress of funds for building a forest fire research laboratory at Missoula. Need for such a facility has been long recognized. The scope of its work will be broadly regional.

Besides studies of fire problems in the West it will be concerned with studies of many problems peculiar to Alaska. A more detailed account of the design of this laboratory will be found in the Forest Fire Research section of this report.

We hope this report will be at once useful and interesting and that you will feel free to ask for additional information on any studies mentioned herein.

Reed W Bailey

Director

FOREST MANAGEMENT RESEARCH

Forest management research at Intermountain Station consists of studies in the following fields: silvics, genetics, natural regeneration, seeding and planting, yield and quality, stand improvement, forest measurements, and pilot operations. This research is centered mainly in the western white pine, western larch--Douglas-fir, and ponderosa pine types with minor effort in lodgepole pine forests. Balancing manpower against commercial forest area, we average approximately one forest management researcher to each 4 million acres of commercial forest land. Although our research is making significant gains, we can hardly meet demands for management information in any of our forest types. Our research program is most deficient in lodgepole pine, Douglas-fir, and Engelmann spruce forests. Yet of the total 14 million acres of lodgepole pine forests in the United States, nearly 9 million acres are in the area served by the Intermountain Station, and in point of growing-stock volume, Douglas-fir leads all species within the station area. Hence the challenge to forest management research at Intermountain to meet the information needs of forest managers is very great.

Although the following pages do not review the forest management research program in detail, they present selected significant items of progress.

The Northern Idaho Forest Genetics Center, located on the campus of University of Idaho, Moscow, officially opened in September.

GENETICS

Northern Idaho Forest Genetics Center

This fall we took another step forward in the cooperative project to improve western white pine. Scientists of Region 1 and of our Inland Empire Research Center moved into a new home at Moscow, Idaho. The Northern Idaho Forest Genetics Center was built there by the Forest Service on land provided by the University of Idaho. The improvements include an office-laboratory, garage, and headhouse with attached greenhouse and extra large lathhouse. A small nursery is available for the production and blister rust inoculation of experimental progenies. This new facility will be the center for future Forest Service efforts to produce rust-resistant white pines of superior growth and form.

On their nearby farm, the university has set aside 40 acres of excellent agricultural land for long-term tests. More than 1,500 rust-resistant F_1 progenies from rust-resistant parents are now growing on 15 acres of this tract; these trees are the nucleus of an experimental breeding orchard. Another plot within this 40-acre tract is being planted for a comprehensive study of seed orchard management. There we shall follow first the effects of fertilizing and watering on flower production and growth. Two levels of irrigation plus three levels of each of three nutrients, N, P, and K, will give 54 test treatments.

Since the project's inception 10 years ago, more than 200 rust-resistant trees have been selected in heavily infected stands throughout the white pine type. Progenies of half of these rust-resistant candidates are now being tested for rust resistance and growth potential. Thirteen field selections already stand out in the rust resistance tests. These resistance transmitters are being multiplied by grafting this winter. Their clones will be outplanted by the Kaniksu National Forest in 1960: our first seed orchard for production of F_1 seed.

How soon can we expect flowers in these breeding and F_1 seed orchards? Early fragmentary returns from several studies show flowers should appear before 10 years have passed. At Emerald Creek, both male and female conelets were produced on one tree during its ninth growing season from seed. Buds containing these conelets formed in 1956 during the second season in which the tree had been fertilized, cultivated, and watered. At Fernwood, a tree in its seventh season bore females, and several trees in their sixth season bore males. These precocious individuals had been clean-cultivated each year, and they had been fertilized in the nursery seedbed during their first and second growing seasons.

Grafting gives similar results. A seedling was grafted into the top of a 25-year-old heavily flowering tree. This year that seedling bore nine female conelets. At another grafting test near Bremerton, Washington, 6-year-olds were grafted into wildlings in May 1956; three of these bore female conelets in 1958.

Generally these grafts are not very successful. We feel that seedlings on their own roots do as well, particularly with cultural treatments; therefore we are striving now to find the optimum level of each fertilizer, cultivation, and irrigation treatment. Every tree in the orchard now receives a dose of complete fertilizer each spring. In addition, we irrigate and cultivate during the growing season.

Growth of Ponderosa Pine in Northern Idaho

Last year we reported progress in analysis of studies of geographic variation in ponderosa pine. Tests at the Priest River Experimental Forest in northern Idaho have shown that 82 percent of the variation in height growth among 20 progenies could be correlated with three variables. Increases in growth were associated with decreasing altitude and increasing longitude and latitude of the seed source. In general, local sources did best.

The height growth of a progeny planted in northern Idaho was found to be closely associated with climatic factors existing at its source. Growth was most strongly correlated with seasonal distribution of precipitation, not the total amount. Seed sources receiving most of their precipitation from September through June grew best. Growth was fairly strongly correlated also with mean April-May temperature. The warmer the spring temperatures at the source, the faster the growth in northern Idaho. Furthermore, spring-summer temperatures were more important in determining growth than were mean annual temperatures. Variation in these two factors--seasonal precipitation and April-May temperature--accounted for 76 percent of the variation in progeny height growth in northern Idaho. Growth was good where climate at the source was similar to climate at the planting site.

NATURAL REGENERATION

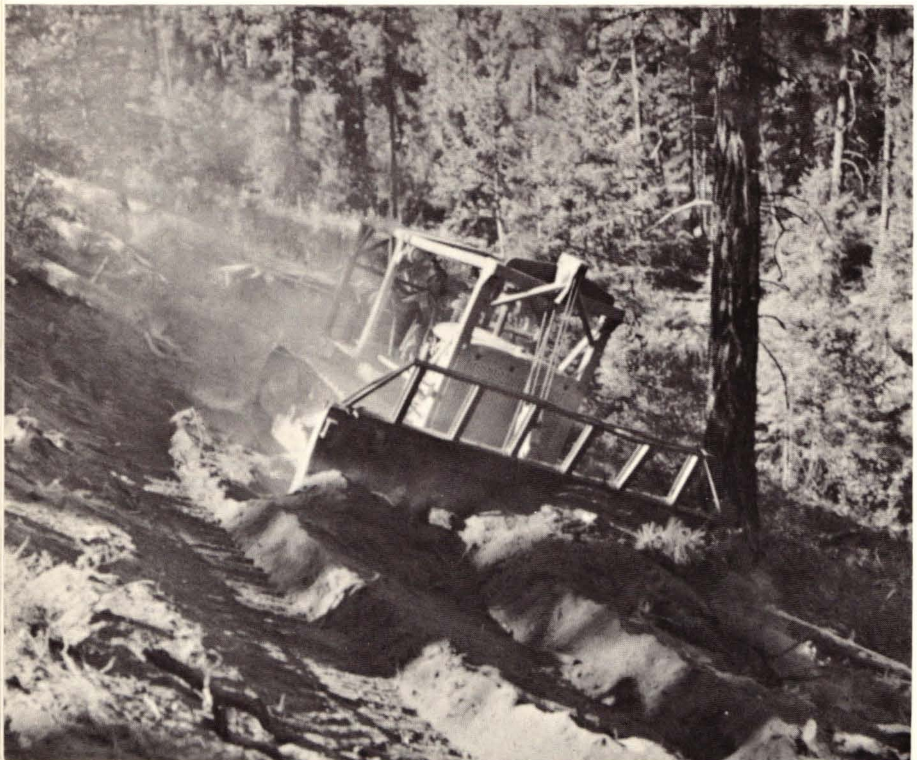
Heavy Ponderosa Pine Seed Crop

In 1958 central Idaho had its heaviest ponderosa pine seed crop since 1940. To take advantage of this situation, some 25 acres on the Boise Basin Experimental Forest were thoroughly scarified. This acreage is made up of small clear cuttings created expressly to establish reproduction in the group selection compartments of our ponderosa pine production study. A Fleco land-clearing blade scarified along contours to a depth of about 16 inches (see accompanying figure). It is hoped that this treatment will establish naturally a crop of seedlings that will comprise the youngest age class in the study of ponderosa pine production. Satisfactory coverage of these areas by seed was confirmed by use of seed traps. Further auxiliary measurements on the establishment of seedlings will continue through the next few growing seasons.

Tree Bands for Cone Protection

Further tests during 1957 and 1958 at the Missoula Research Center of a method for protecting tree cones from cutting by red squirrels show that 14-inch-wide bands are the minimum size that can be used safely. Earlier studies reported in the Journal of Forestry1/ demonstrated that an 18-inch-wide, smooth aluminum band prevented squirrels from climbing the trees and cutting cones and cone-bearing branches. Bands should be attached to the trees so their upper edge is at least 7 feet above ground line on the uphill side of the tree.

1/ Tackle, David. Protection of ponderosa pine cones from cutting by the red squirrel. Jour. Forestry 55: 446-447. 1957.



To take advantage of a heavy ponderosa pine seed crop, this D7 tractor, equipped with a Fleco land clearing blade, is scarifying along contours in a clear cutting within a group selection compartment, Boise Basin Experimental Forest.

Seed Dispersal in the Western Larch--Douglas-fir Type

Seed dispersal on the Coram Experimental Forest, Montana, in the western larch--Douglas-fir type varies significantly by year and direction and distance from seed source. These conclusions are based on 6 years of study on three square, clear-cut blocks (15, 30, and 60 acres, respectively) that were cut on north-facing slopes in 1952. Overmature western larch and Douglas-fir made up most of the dominant and codominant height classes. The residual larch averages 130 feet in height and the Douglas-fir 100 feet. There is an average of 33.7 larch and 17.3 Douglas-fir trees per acre larger than 10 inches in diameter.

During the study period seed production trends for larch and Douglas-fir were similar. Soundness was greatest during years of high production and decreased as production diminished. A definite but not significant decrease in soundness was apparent beyond 4 chains for larch and 6 chains for Douglas-fir within the clear-cut blocks. The pattern of seed production per acre and soundness for the 6-year period was as follows:

Year	Seed crop rating	Western larch		Douglas-fir	
		Sound seed	Soundness	Sound seed	Soundness
		Number	Percent	Number	Percent
1952	Good	411	42.4	181	43.6
1953	Near failure	4	4.9	1	10.0
1954	Good	1,248	33.2	301	37.7
1955	Poor	29	21.5	6	20.7
1956	Near failure	2	10.0	1	7.7
1957	Poor	37	17.1	5	19.2

Seed fall decreased rapidly from timber edge to 6 chains for larch and 4 chains for Douglas-fir, then stayed at a fairly constant level to the center of the 60-acre block. On each block an average of 61,000 sound larch and 16,000 Douglas-fir seeds was dispersed per acre 6 chains and beyond during the first 5 years after cutting. These amounts represent 4.5 and 3.7 percent, respectively, of the estimated sound larch and Douglas-fir seed produced within the timber during the same period. Virtually no seed was dispersed beyond 4 chains except during good seed years (1952 and 1954).

Significantly more larch seed was dispersed uphill into all the clearcut blocks than in any other direction. Douglas-fir seed fall had a similar pattern, but differences in direction of dispersal were not statistically significant. Because the normal prevailing winds are not from the downhill sides in this area, it is theorized that most of the seed was released from the cones and dispersed uphill by dry thermal winds.

SEEDING AND PLANTING

Planting Ponderosa Pine

New experiments in techniques of planting ponderosa pine were started, and others already under way were continued in 1958. Tentative conclusions from one experiment suggest that while a powered auger can dig suitable holes more quickly than hand methods, and while these holes result in slightly higher survival of planted stock, operation of the powered auger is too fatiguing to be widely applicable. Another experiment demonstrated that on "problem" (unproductive) openings in the ponderosa pine type, too steep to be scarified conventionally, benchlike "contourings" can be constructed, suitably spaced, and planted successfully. Two-year-old seedling nursery stock is preferable to 1-year-old seedlings in cardboard containers; use of this 2-year-old stock results in acceptable survival, occasionally as high as 100 percent. Survival of plantings on the inside of the contourings was significantly higher than for plantings in the middle; but plantings in the middle of contours consistently survived better than those on the berm. On all aspects, survival of out-planted 2-year-old seedlings was higher than that of 1-year-old seedlings set out in paper and cardboard containers.

Aerial spraying by helicopter of 40 acres of brushfield with 2,4,5-T, 2,4-D, and Dowpon in four mixtures each on 10-acre plots resulted in a proportion of crown-kill that had been anticipated. A respray of this area is planned for the summer of 1959 preparatory to planting in 1960 without further site preparation. Survival of 2-year-old stock planted in plow furrows on both hand-sprayed and unsprayed brush areas ranged upwards from 86.7 percent.

The 1-year survival count on the final (1958) planting and the 5-year survival count of the 1954 planting at Town Creek, together with the results of the more modest-sized experiments just described, suggest strongly that care of planting stock from lifting to planting; care in the field planting operation; and generous elimination of vegetation that is competing, or probably will compete, with the planted seedling, are all of paramount and equal importance in the success of planting in central Idaho.

Spacing Studies in Western White Pine and Associated Species

In recent years, plantation spacing tests have taken an important place in studies of growing stock densities. These studies advantageously provide a high degree of experimental control not easily obtained in thinning studies. In addition, they eventually will provide information that will be useful in the practical application of artificial regeneration.

The first phase of the spacing test program in western white pine was established at our Deception Creek Experimental Forest in 1957. A 25-acre, north slope clear cutting was planted to white pine in three replications of five different spacings: 5, 7, 10, 14, and 20 feet. These spacings give each tree a growing space of 25, 49, 100, 196, and 400 square feet, respectively. Fill-in plantings will bring the first year survival of 91 percent up to as near 100 percent as is possible, and any wildings will be removed to provide a high degree of growing space control. Portions of each plot have been reserved for future tests of cultural treatments.

Additional replications of this spacing study will be established in 1959 and 1960. In the spring of 1959 at least two replications will be made on the Clearwater National Forest, and in the fall of 1959 we shall plant again at Deception Creek on a 65-acre south slope clear cutting. This test will include white pine, Douglas-fir, grand fir, and possibly ponderosa pine.

In all of these studies, basic information on soil moisture utilization, root and crown growth, and lesser vegetation competition will be sought as well as empirical information on growth and yield.

YIELD AND QUALITY

Growth of Residual Lodgepole Pine

Large growth losses result when heavy partial cuttings are made in overmature lodgepole pine stands in Montana. This conclusion, reached through earlier surveys, has now been confirmed by results from an 11-year-old study on the Gallatin National Forest near Bozeman.

The study was conducted in a pure, even-aged, overmature stand cut for pulpwood in 1947. The original stand 3 inches d.b.h. and larger had a basal area of 115 square feet and a volume of 4,407 cubic feet; the original stand 7 inches d.b.h. and larger contained 19,176 board feet. Timber harvest removed 71 percent of the basal area, 73 percent of the cubic-foot volume, and 76 percent of the board-foot volume.

Growth of the residual stand in terms of basal area and cubic- and board-foot volume is shown in the following table.

Growth of residual stand per acre

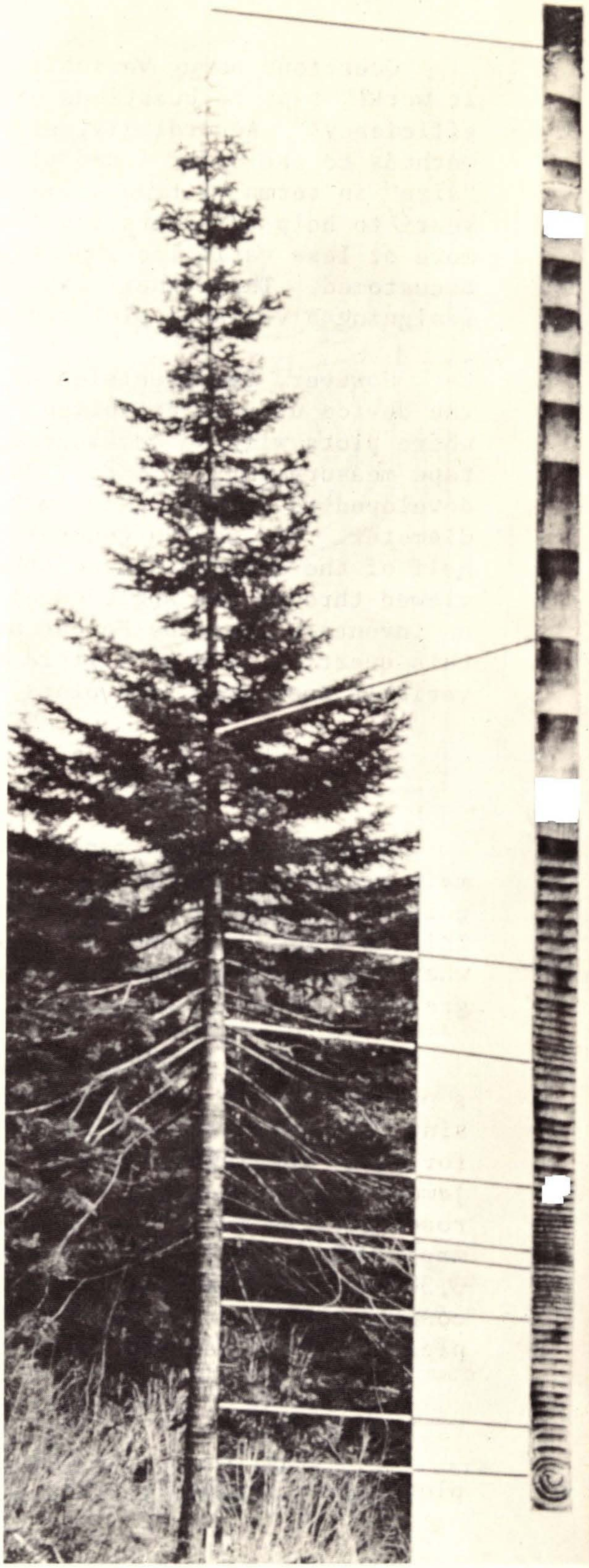
Residual stand	Stand 3 inches d.b.h. and larger			Stand 7 inches d.b.h. and larger	
	Trees	Basal area	Volume	Trees	Volume
	Number	Sq. ft.	Cu. ft.	Number	Bd. ft.
1947	99.0	32.9	1,201.9	60.0	4,621
1957	56.0	15.2	538.4	29.0	2,135
Net 11-year growth	-43.0	-17.7	-663.5	-31.0	-2,486
Periodic annual growth	-3.9	-1.6	-60.3	-2.8	-226

Eleven years after cutting, the stand is seriously damaged. Most of the mortality was caused by windthrow and wind breakage. Many residual stems were snapped off from 3 to 50 feet above ground.

Grand Fir Growth and Yield Study

Grand fir, the species fourth in volume in Inland Empire forests and highly preferred for pulp manufacture, has a high growth potential. How are sites classified for grand fir? How does density affect growth? How much volume production per acre is attainable? These questions need answering for improved management of this species.

To provide a means of rating grand fir sites, trees have been felled and sectioned to determine their ages and rates of height and diameter increment. This phase of the study covered a range of forest and habitat types extending from areas on which grand fir is the climax species up to the zone of spruce and subalpine fir climax. From these data, site index curves and height growth information can be derived. Site classification in many stands is complicated by the response of grand fir to release. The accompanying figure illustrates the concomitant effects of release on height and diameter growth of a tree 84 years old at the time the stand was cut in 1943. Fifty-seven percent of its present diameter and 55 percent of its height have been attained in the 14 years since the stand was cut.



Height and d.b.h. growth, shown by 10-year periods, of a 98-year-old grand fir tree released by logging 14 years previously (Deception Creek Experimental Forest).

FOREST MEASUREMENTS

Questions about variable plot cruising have shifted from the early "Does it work?" type to questions of "Where and how can we best use it for maximum efficiency?" Accordingly, effort has been made to relate variable plot methods to the older fixed plot methods. A chart expressing variable plot "size" in terms of tree diameter and the basal area factor was published this year[2/] to help foresters tell whether a given variable plot cruise should have more or less variation than the type of cruising to which they have been accustomed. Thus, their experience with fixed area plots can be applied to designing a variable plot cruise so as to achieve the desired accuracy.

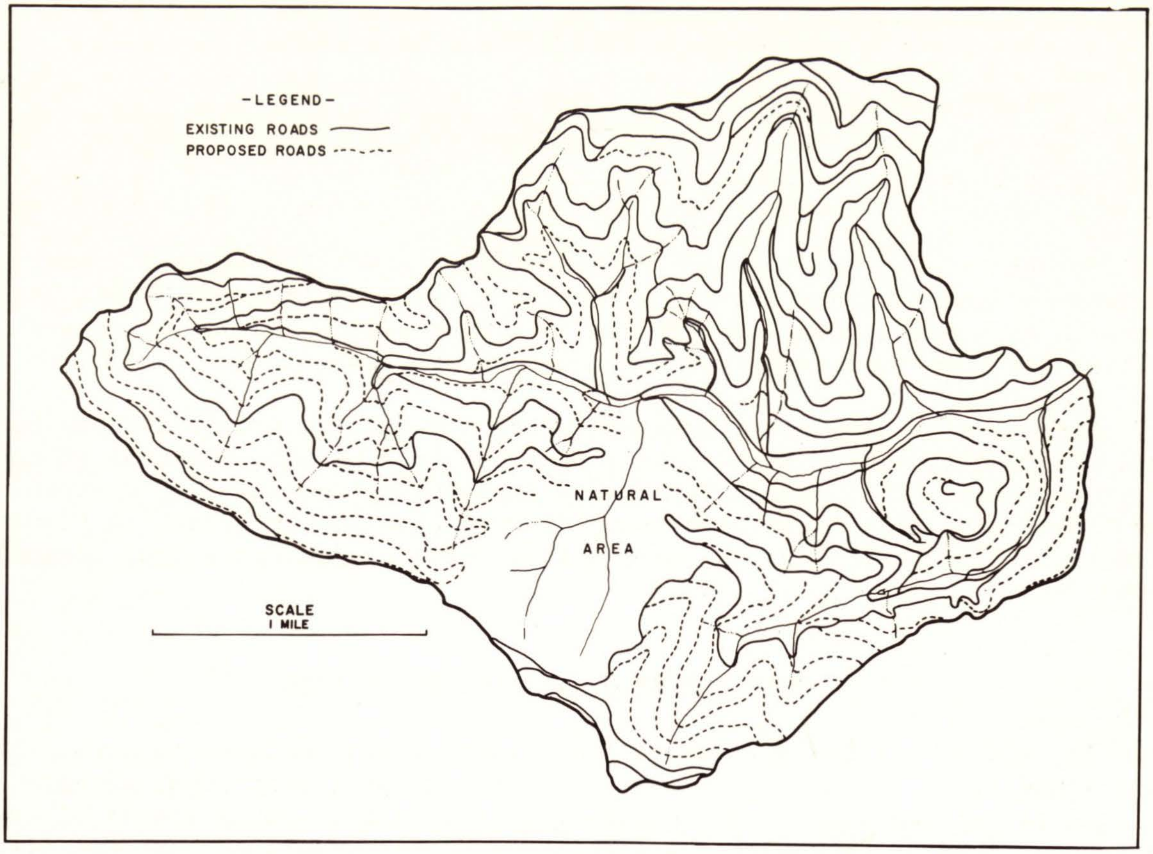
However, the precision of a variable plot cruise is also dependent on the device used to establish "plot" boundaries. For very accurate work, where plots will be remeasured, doubtful trees must be carefully checked by tape measurements. To facilitate these measurements, a slide rule was developed to compute the limiting slope distance for a tree of any given diameter. For use on general cruising, can we rely on the assumption that half of the marginal trees (those that are neither clearly "in" or "out" as viewed through the angle gage) should be tallied? Data collected during 1958 on inventory plots by Forest Survey and Region 1 will provide the answer to this question, and will yield further data on the relative variation of variable and fixed area plots.

PILOT OPERATIONS

Intensive forest management depends upon well planned access, both by main haul roads and logging spurs. Not until such access is completed can a unit be adequately protected and cultured for maximum sustained production. This is especially true in areas managed for production of western white pine where we are committed to intensive management and the production of the greatest volume of white pine.

Accordingly, the development of a permanent logging road system has been a primary aim in the management of the Deception Creek Experimental Forest since its establishment 25 years ago. The system plan, originally designed for horse logging and jammer skidding, has been altered slightly to adapt to jammer logging methods. At the outset the plans called for a few climbing roads serving many "contour" logging roads spaced 400-600 feet apart (see map). When the system is completed, it will have 80 miles of road serving 3,300 acres, or a road intensity of about 16 miles per section. With the construction of 8 miles of road in 1958, the system is about two-thirds completed. Plans call for completion of the system by 1965.

[2/] Stage, A. R. An aid for comparing variable plot radius with fixed plot radius cruise designs. Jour. Forestry 56: 593. 1958.



Permanent contour logging roads, averaging 16 miles per section, and main haul climbing roads at Deception Creek Experimental Forest.

A road system of this intensity occupies 10 to 12 percent of the area and results in some reduction of productivity. But what is lost in production along road rights-of-way is more than compensated for by lowered protection costs, the opportunity for salvage and sanitation logging, and by the chances for silvicultural manipulations of the adjacent stands throughout their lives.

At Deception Creek the existing road system plays a vital part in a continuing salvage logging of scattered trees that have died from wind, beetles, and snow breakage. Salvage and sanitation cuttings during the past 10 years have harvested nearly 7,000,000 board feet of timber and yielded more than $97,000 in stumpage returns. In addition, these cuttings have financed much of the road construction. In the last 5 years, salvage of scattered trees from existing roads, which serve about 1,200 acres, has averaged nearly 80,000 board feet per year. This continuing salvage would be impossible were it not for the intensive road system that serves the experimental forest.

FOREST DISEASE RESEARCH

Forest tree diseases create some of the greatest problems of timber management in Intermountain Station's territory. The Division of Forest Disease Research is concentrating its efforts in both research and survey toward solving the more important of these numerous problems.

Successful management of western white pine hinges primarily upon being able to cope with white pine blister rust and pole blight. Control of the dwarfmistletoes is of utmost importance in managing Douglas-fir, western larch, and lodgepole pine. Other perplexing disease problems important in timber management involve control of the native stem rusts of ponderosa and lodgepole pines.

POLE BLIGHT OF WESTERN WHITE PINE

In 1958 we started a study of tree growth rings designed to provide better understanding of the nature of the soil moisture deficiency that appears to be related to incidence and development of pole blight in young stands of western white pine, and to determine the likelihood of recurrence of such deficiency.

We completed field work on a dendroclimatological study using western white pine as the test species. Objectives of this study were:

1. To determine approximate frequency of drought or dry cycles within the western white pine type during the past two or three centuries. Specifically we wished to learn whether any past cycle was as dry or lasted as long as the one that started about 1917 and reached its peak in 1929 and 1930.

2. To compare growth of trees in different age classes through the first years of their life and thus determine whether the recent climate, as reflected by growth in the 70-year-old age class, was different from the climate that older trees underwent when they were growing to age 70.

3. To compare growth of trees now in the 70-year-age class on sites having various storage capacities for available moisture. This growth study includes comparison of growth of healthy and diseased trees within diseased stands with growth in healthy stands--both adjacent to diseased stands and outside the pole blight range; it was also designed to determine whether growth on residual healthy trees in diseased stands has returned to normal.

Results await analyses of increment cores and field data.

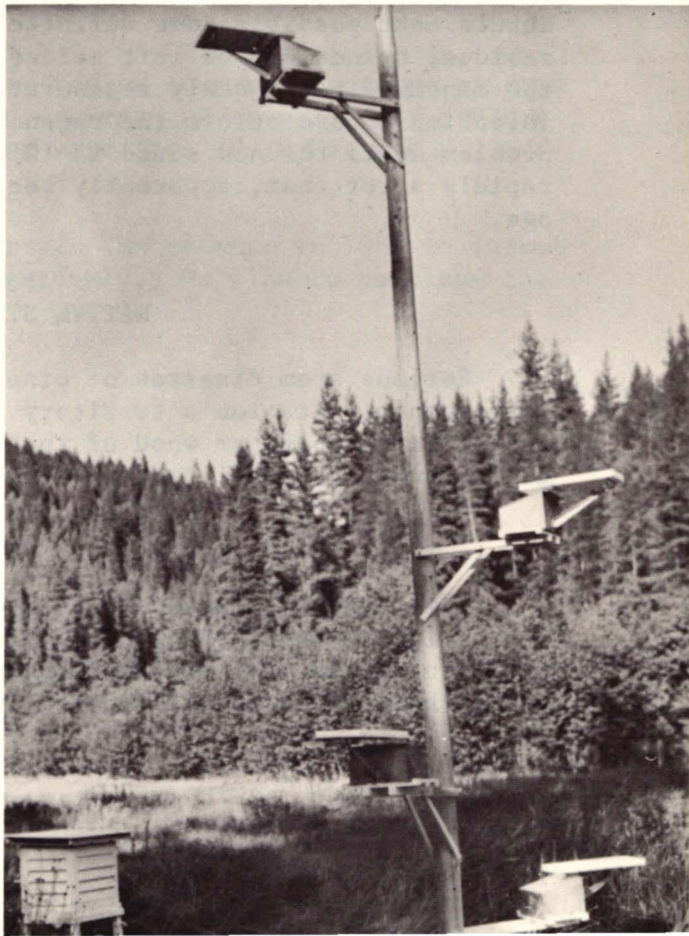
WHITE PINE BLISTER RUST MICROCLIMATE

Saturated air and free water on the leaves are required for production and germination of spores in the various stages of blister rust disease. The length of time the plant surface remains wet is important in determining whether spores can germinate and penetrate their host plant. Therefore occurrence and duration of moist periods during the time that viable spores of the various spore stages are present can influence intensification of rust on the ribes and its spread to the pine.

Dew Recorder Developed and Tested

Rain, fog, and dew may deposit water on plant surfaces, but standard meteorological instruments provide data only on the time and amount of rainfall. To obtain data on duration and amount of dew under the variety of topographic and vegetative conditions encountered in the Inland Empire's white pine belt, seven recording instruments, originally developed to record variation in weight of fuel moisture sticks, were modified to measure these periods and amounts of fog and dew.

Each instrument was modified by replacing the fuel moisture stick normally on its mountings with a block of expanded polystyrene. When the unit is on the ground, the polystyrene block is about 1 foot above ground and gives measurements of dew deposit at near the average height of a ribes bush, the secondary host of the rust. This dew recorder was tested under a wide variety of conditions at the Priest River Experimental Forest during the summer and early fall. Mechanical difficulties resulted in a few gaps in data, but performance of the device was generally satisfactory, and we expect to gather considerable important information from it next season.



Dew recorders mounted at 2, 5, 10, and 20 feet above ground in a meadow near Benton Creek, Priest River Experimental Forest.

WHITE PINE BLISTER RUST DAMAGE STUDY

A permanent study plot containing 88 trees was established in 1955 to determine the rate at which damage and death occur in mature western white pine trees as a result of established blister rust cankers. At that time we estimated how long it would take the blister rust cankers to top-flag trees or to kill the trees following top-flagging. Examination of the study plot in 1958 showed that 15 of the mature trees have already died--at an average of 12.5 years earlier than the time estimated for their death. Another 25 trees top-flagged an average of 2.76 years prior to the time estimated for it. Still another 7 top-flagged either above or below the cankers believed to have been most lethal.

DWARFMISTLETOES

In 1958, we analyzed the dwarfmistletoe problems and situations in the Douglas-fir, lodgepole pine, and western larch types in Region 1. We shall propose research projects aimed at providing guidelines for silvicultural control of these parasites; these proposals will be based on the analyses made last year.

Limited studies on the rate of spread and intensification of the lodgepole pine dwarfmistletoe confirmed generally the observations previously made by the Rocky Mountain Forest and Range Experiment Station. Rate of spread in dense stands averaged about 2 feet per year, compared with about 1.5 feet of spread in similar stands in the central Rockies. Very little further study should make possible some definite recommendations on the length of time residual stands can be left before they should be cut to keep infection to the minimum in the newly regenerated stand. Present studies indicate that no infection occurs before the regeneration is 7 years old. Infection is a minor problem until the new stand is 10 years old; but infection percentages increase rapidly after that, apparently because target area increases rapidly after this age.

NATIVE STEM RUSTS OF PINES

Serious stem diseases of pines are caused by several native rust fungi in Intermountain Station's territory. Since the mycelium of these fungi is perennial in the bark or wood of their pine hosts, various malformations such as galls, burls or swellings, and cankers develop and often kill the host tree.

Limb Rust

This disease, caused by Peridermium filamentosum, attacks ponderosa pine in the Intermountain region only, mainly in southern Utah. The fungus is a native organism that has been known there on that host for more than 35 years. It has been found attacking seedlings, but it appears most commonly in second growth or blackjack and mature trees. On some areas in the sample plots in cutover stands as many as 25 percent of the remaining trees over 3.6 inches d.b.h. were diseased.

Indian paintbrush (*Castilleja* spp.) has been reported as alternate host of this fungus. Although these plants, particularly *C. linariaefolia*, are common in many diseased stands, we rarely find one of them even lightly infected. Several attempts to infect *C. linariaefolia* and *C. rhexifolia* with aeciospores failed.

Recent evidence from a limited test demonstrated that an alternate host may not always be necessary in the life cycle of *P. filamentosum*. Pine inoculations were also made with telia from infected *C. linariaefolia* growing in association with diseased trees, but no infection developed from these inoculations. Results obtained from these studies may be significant in control of the rust. We plan additional aeciospore inoculations involving a larger test basis and improved technique.

White Peridermium Gall Rust of Ponderosa Pine

The fungus that causes this gall has not yet been positively identified: it may be an undescribed species. All described species of *Peridermium* inhabiting bark have aeciospores that are either a yellowish or an orange color. This fungus has "white" aeciospores and is therefore tentatively referred to as an "albino" form possibly of *P. harknessii*. The galls are globose to pear-shaped, mainly the latter, and have a prominent bark collar at each end. Aecia are separate and borne on the bark surface, not under bark scales and confluent as is typical of *P. harknessii*.

This rust is known in the Intermountain region only on ponderosa pine in Utah. It causes galls on branches and "hip cankers" on trunks. Hip cankers have been observed on mature trees measuring more than 40 inches d.b.h., and cause considerable cull in butt logs.

We know of no alternate host of this rust. An attempt in 1952 to infect *C. rhexifolia* with aeciospores resulted negatively. We plan to continue the history studies on this fungus.

FOREST DISEASE SURVEYS

We conducted disease surveys by special systematic coverage and observational methods for pole blight and the dwarfmistletoes. Surveys reported herein for other diseases consisted of general observations made during other field work.

Pole Blight

The last intensive survey of the distribution of western white pine pole blight was made in 1953. During 1958, 20 hours' flying time was spent on an aerial resurvey. Suspected areas observed from the air were mapped and later examined on the ground for confirmation. The flights covered 72 selected pole stands that contained 27 suspected areas. Of these, 13 areas were confirmed as having pole blight, but only two of these had not been located in the 1953 survey. This 1958 resurvey indicates that pole blight is confined largely to the areas designated as affected in 1953. Within them, however, the disease is still very active except in a few localities.

Dwarfmistletoe

We concentrated survey activity in western Montana to appraise the dwarfmistletoe situation in the Clark Fork Timber Development Unit. The survey collected information on the abundance and severity of dwarfmistletoe so that its effects on the timber resource of the unit could be estimated. The sampling included 2,090 1/10-acre plots in 209 townships. Of these, 35 percent either contained infected trees or were located in infected stands. Infected trees of one or more species (Douglas-fir, western larch, lodgepole pine) were found on 474 (23 percent) of the plots. Lodgepole pine dwarfmistletoe was found throughout the area, and infected western larch was found wherever larch was growing. The Douglas-fir dwarfmistletoe was prevalent in the western part of the area, but was absent from the eastern part. Other species were almost entirely free of dwarfmistletoe.

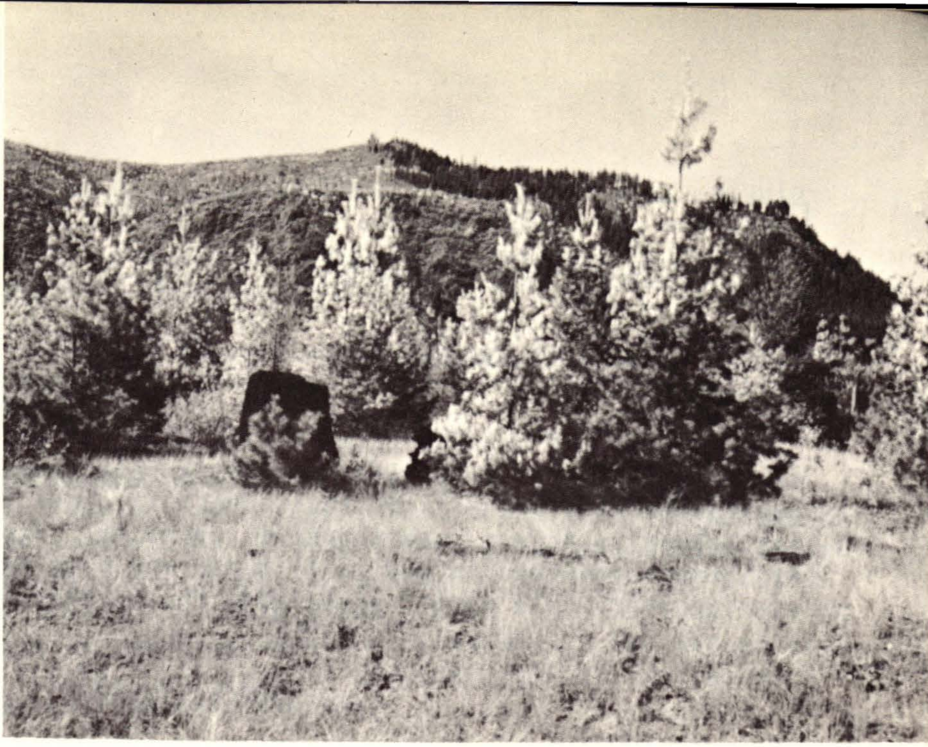
Poria Root Rot

We examined many Douglas-fir stands, especially those east of the Bitterroot Range and east of the western white pine range, for *Poria weirii* root rot. Although this rot has been found in many stands within the white pine type, we have not yet seen it east of the Bitterroot Range in Montana except in the eastern limits of the white pine range.

Needle Diseases

Needle diseases were very common this year on several coniferous species. The larch needle cast was more prevalent this year wherever western larch occurs in the region than it has been for many years. The Douglas-fir needle blight, relatively unimportant the past few years, flared up in many areas. The Elytroderma needle blight on ponderosa pine appeared to intensify in the known areas of infection, but no new areas of infection were reported or observed.

Summer drought injury to a western white pine plantation in northern Idaho in 1958. Many trees were killed, while tops of others were partially killed back. A western larch tree, directly behind the black stump, has been defoliated by the drought.



Summer Drought Injury

In the fall we observed drought injury to western white pine, grand fir, lodgepole pine, and possibly to western larch in various parts of the Kootenai, Coeur d'Alene, St. Joe, and Kaniksu National Forests. Damage areas were quite scattered in natural reproduction, and injury was generally limited to a few seedlings and saplings (up to 25 feet tall) per acre. The only extensive area of severe damage found was located in a 17-year-old western white pine plantation in the Priest River drainage, where about half the trees were damaged. Other drought damage to saplings of Douglas-fir and ponderosa pine was reported from severe sites north of Newport, Washington.

FOREST INSECT RESEARCH

The work of this division during 1958 was mainly of three kinds: studies of individual insect species (including relationship of these insects to their environment and methods for their control), insect surveys, and technical assistance to forest insect control projects. Since the nature of technical assistance rendered is generally known and does not change substantially from year to year, this report highlights the research studies and the surveys.

INSECT STUDIES

Spruce Budworm

During the present outbreak, which has lasted nearly 10 years, Choristoneura fumiferana (Clem.) has been very active over large areas of Douglas-fir and true firs in Montana and Idaho. Two major studies have been under way for several years, one designed to determine population trends of the budworm and its natural enemies, and the other to relate the amount of defoliation to subsequent damage to individual trees and forest stands.

An important phase of the study of budworm population trends and enemies has been investigation of several insect parasites of the budworm that are especially important in the northern Rockies. These insect parasites may be divided into four groups, depending on whether they attack the egg, the young larvae, the mature larvae, or the pupae of the host.

During this study the minute egg parasite, Trichogramma minutum Riley, has destroyed less than 1 percent of the eggs. Occasionally it has heavily parasitized individual egg masses, but forestwide it shows no promise of becoming an important parasite.

Two parasites of the young larvae are the wasps Glypta fumiferanae (Viereck) and Apanteles fumiferanae Viereck. They parasitize the small budworm larvae in late summer and hibernate as eggs or first stage larvae within the host. The caterpillar is killed in the fourth or fifth instar the following summer, and the parasite larvae emerge and spin their cocoons in the foliage. These are the most common budworm parasites in Montana, and they are especially important because they kill the host long before maximum feeding damage has occurred.

Parasites of the mature larvae in this region include several genera of tachinid flies, a sarcophagid fly, Pseudosarcophaga affinis (Fallen), and a wasp, Phytodietus fumiferanae Rohwer. The flies parasitized about 15 percent of the mature budworm larvae at the Clinton plots in 1956, but their population has decreased since then. In the other plots the flies have not been numerous. Phytodietus, though considered an important parasite in British Columbia, has been ineffective in Montana.

The parasites of the pupae are the two wasps Phaeogenes hariolus (Cresson) and Itoplectis sp. Phaeogenes, the more common, sometimes parasitizes 10 percent of the pupae.

One source of our information on abundance of Glypta and Apanteles is the bole sections that have been cut each spring from trees in budworm control areas to determine prespray populations of overwintering larvae. Larvae reared from bole sections have always shown Glypta to outnumber Apanteles by ratios of 2-to-1 to 10-to-1 or greater. Since Glypta has a much longer ovipositor, it has advantage over Apanteles in reaching larvae hibernating in the deeper fissures of the bark of tree trunks. This should account for the preponderance of Glypta in the larvae reared from bole sections.

In 1958 we performed an experiment to determine the incidence of Apanteles and Glypta in overwintering larvae from different parts of the crown. Relative abundance varied according to location of the larvae in various parts of the crown.

Parasitism by Glypta and Apanteles has increased progressively for several years. In 1958 it varied from 26 to 60 percent, and averaged nearly 40 percent. Examination of more than 13,000 budworm larvae taken at 13 localities in six national forests in Region 1 and in Yellowstone National Park showed that more than 3,500 (about 26.4 percent) had been parasitized by Glypta, and nearly 1,800 (about 13.2 percent) had been parasitized by Apanteles.

Effectiveness of both Glypta and Apanteles may be seriously curtailed by hyperparasites. Apanteles seems particularly prone to parasitism by a variety of species, most of which have not yet been identified. The most common hyperparasite of the spruce budworm is a small chalcidoid wasp, Amblymerus verditer (Norton). This insect has a wide range of hosts, having been reared in local studies from Hymenoptera: Apanteles, Glypta, Horogenes, Phaeogenes, and Phytodietus; Diptera: Actia, Aplomyia, Ceromasia, Madremyia, and Phorocera; Lepidoptera: spruce budworm, black-headed budworm, Dioryctria reniculella. Amblymerus emerges from the pupae of the last three named species, within which we commonly find remains of a dead ichneumonid primary parasite. Amblymerus may sometimes function as a primary parasite of these moths or of another defoliator from which it is commonly reared, namely, the hemlock sawfly. We plan further research on the effects of hyperparasitism of the spruce budworm.

Douglas-fir Beetle

Rate of tree-killing by the Douglas-fir beetle, Dendroctonus pseudotsugae Hopk., increases and decreases abruptly in interior stands without evident cause. To learn more about this mystifying behavior, we began a study in southern Idaho in 1956 to explore factors affecting rise and fall of the beetle population. Results will be used to determine need for control and to improve control practices.

We first studied methods of sampling the beetle population. Then we catalogued and assessed importance of natural control factors. The following is a summary of results.

The Douglas-fir beetle produces one generation per year. Most of the brood overwinter as callow adults. Main flight period in southern Idaho occurs in mid-May. Because the beetle spends all but a few hours of its life under the bark, it is impossible to observe directly the changes in population. The immature population must be measured after removing a unit of bark, but surviving adults may be counted by caging the infested material prior to beetle emergence.

Sampling

Among questions facing early investigations were: How is the beetle population distributed in a tree? What units of sample are needed to measure populations in immature as well as adult stages? Where should the samples be located?

Observation showed that beetles preferred down trees and that distribution of attacks differed on down and standing trees. Down trees had to be sampled on the shaded underside where beetles concentrated their attacks. Three zones of infestation occurred in standing trees. Best sampling site was between 9 feet above ground and approximately 5 feet below the top of the infested length.

Standing trees were sampled at a height above 9 feet where study had shown the bark beetle population was more uniform.

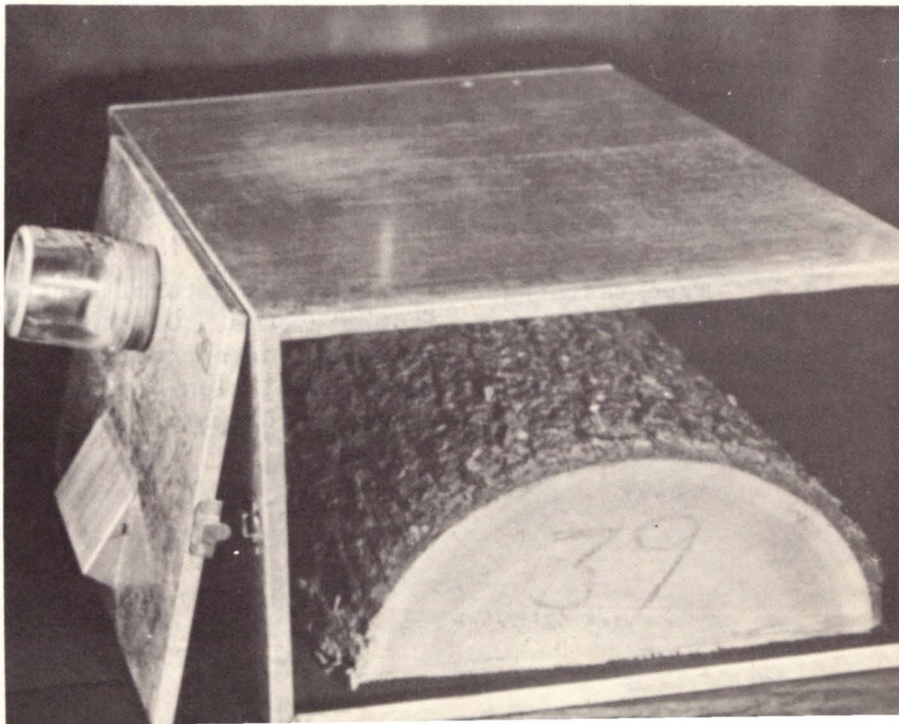
The unit of sample chosen for measuring immature broods was a 6"x12" piece of bark, its length oriented with the beetle egg galleries (i.e., vertically). Samples from 227 standing trees taken during the four seasons, 1955-1958, had an average of 9 egg galleries, each averaging 37.6 inches in length. Similar samples from 81 down trees taken during the three seasons, 1956-1958, had an average of 3.7 galleries with average length of 17.6 inches. In other words, average density of egg galleries in standing trees was 2.4 times greater than that in down trees (windthrow and cull logs) during the period 1955-1958. Two reasons for difference in density between down and standing trees may have been: (1) abundance of down trees diluted the available population, and (2) live standing trees resisted attacks of light intensity.

Survival of brood from 2 to 3 months after eggs were laid was determined by comparing live brood on 6"x12" samples with estimated initial population, which, in turn, was computed by multiplying length of egg galleries on samples by an average number of eggs (7.93) laid per inch of gallery. Estimated average survival of broods sampled on standing trees through the three seasons, 1956-1958, was 26+, or 8.6 percent. On down trees the estimated brood survival was 35.6, or 25.6 percent.

Estimates of survival indicate that most brood mortality occurred during the first few months, and that percentage of survival in down trees was about three times as great as that in standing trees. Because density of attack was less in down trees, less competition among the brood may have been involved in increased survival.

Cages placed around infested trees proved less advantageous for measuring emerged adults than did rearing from bark slabs in the insectary. Untreated slabs produced emerged adults in numbers equal to those from paired slabs dipped in paraffin. A disadvantage of paraffin-treated slabs was that

Survival of overwintered Douglas-fir beetle brood was determined by confining infested bark slabs in ventilated metal cages. A jar in the front served as a trap for emerged insects.



their moistness fostered fungus growth that obscured egg galleries and larval mines. Comparison of number of attacks and of emergence of beetles cut from Douglas-fir trees, both down and standing, indicated that survival in down trees continued higher throughout development of the brood.

Natural Control Factors

Our studies of the beetle revealed several natural control factors of varying importance, including parasites, predators, and tree resistance. Among the many organisms found associated with the beetle were some well known predators, others that seemed to have no direct effect, and still others that had to be placed in "questioned" status pending further study of their identity and habits. Prominent in this last group were various mites. Some mites are believed to prey upon beetle eggs and young larvae; they use the beetle as a means of transportation. We have not yet fully identified any of these mites, but those most commonly found on adult beetles belonged to the genera *Ensliniella* and *Parasites*.

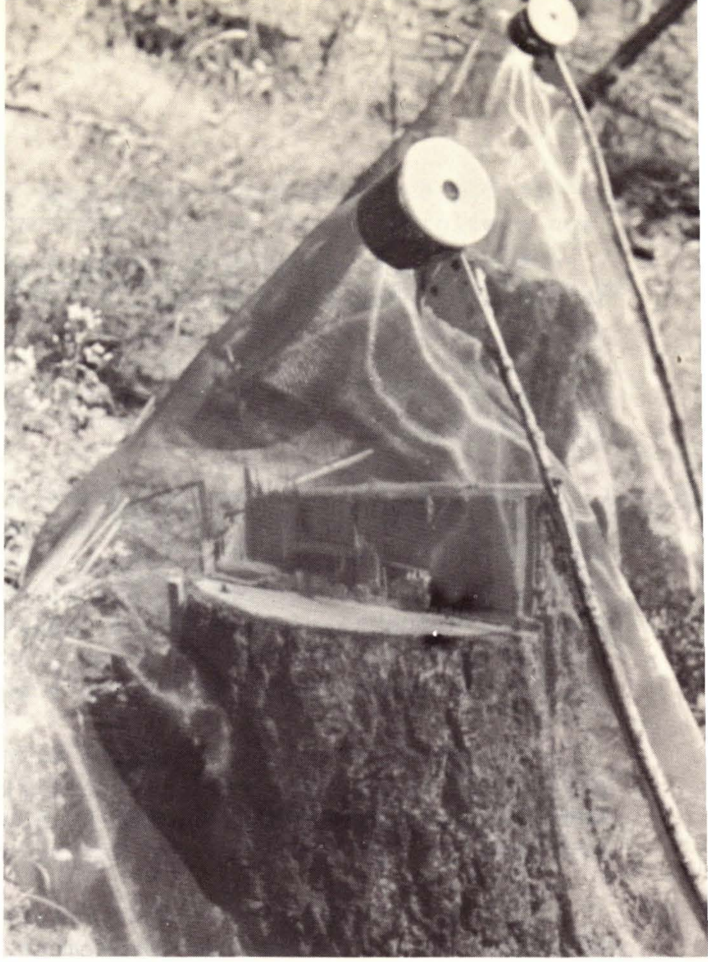
Coeloides brunneri Vier. (Braconidae) is a common parasite of the beetle larvae. The female wasp locates mature larvae under the bark by sound. Mortality due to this wasp was assessed readily because each parasite larva destroys just one beetle larva and then spins a cocoon that remains as evidence of its presence. This parasite varied considerably in abundance from tree to tree, and seemed to be less effective in thick bark areas; also, it was less abundant and less common in appearance on down trees than on standing trees.

Examination of 330 beetles from 35 trees showed 17,500 ectoparasitic and about 89,000 endoparasitic nematodes divided among 5 species. We have not yet studied their effect on hosts.

The most effective predators we encountered were two beetles and several flies. During this study, population of the beetle *Enoclerus sphegeus* Fab. (Cleridae) has remained steady; but *Temnochila virescens chlorodia* (Mann.) declined 88 percent on midsummer bark samples between 1957 and 1958. Also, the number of trees killed by the Douglas-fir beetle increased sharply during this same period. We studied abundance of overwintered *E. sphegeus* and the period of its emergence by using cages like the one shown in the illustration. *Medetera* spp. (Dolychopodidae) have increased in both abundance and importance since this study began.

Tree resistance is a powerful natural control factor. In 1956 we tallied 203 attacked trees in 6 loss groups. Of these, 63 (31 percent) were attacked unsuccessfully (i.e., no larvae were produced). If these attacks had been successful, a larger beetle population would have resulted. Even among successfully attacked trees approximately 5 percent of the attacks were unsuccessful.

Cages placed over infested stumps were used to study abundance and emergence of Enoclerus sphegeus, a predator of the Douglas-fir beetle. Emerged adults were trapped at the top of the cage.



Recommendation for Reducing Damage

Our study of the Douglas-fir beetle has established the facts that beetles prefer down trees and that brood survival is greater there than in standing trees. Average age of infested standing trees was greater than 150 years. Most losses have occurred in unmanaged stands. Cull logs left after logging breed up increased populations of beetles; but continued logging in the same area may keep the beetles constantly in down trees if fresh material is available to them during the May flight period.

Our findings to date prompt the following recommendations for managing Douglas-fir in southern Idaho:

- Windthrown trees should be salvaged promptly wherever possible.

- Mature and overmature Douglas-fir should be harvested so as to leave a young, vigorously growing stand well able to absorb the attacks of normal beetle populations.

Spruce Spider Mite

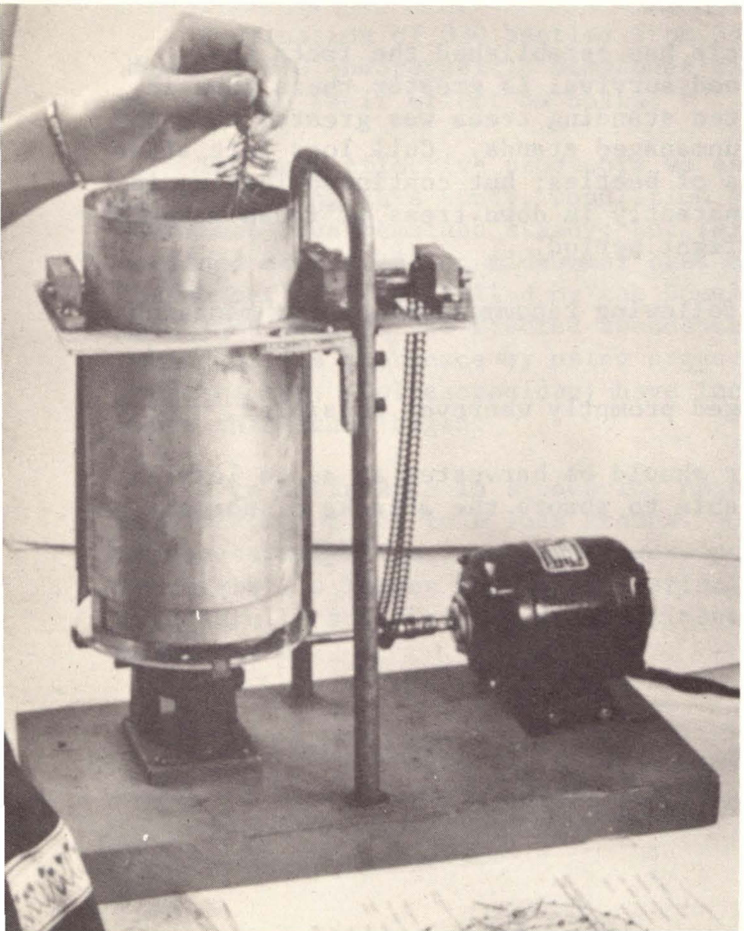
The spruce spider mite, Oligonychus ununguis (Jacobi), first appeared in damaging numbers in Montana in 1957 on Douglas-fir following aerial spraying operations in 1956. Because the appearance of browned foliage, resulting from mite feeding, coincided with the areas that had been sprayed to control spruce budworm, the problem of mite populations immediately assumed considerable importance.

National Forest Administration and Intermountain Station cooperated to conduct aerial spraying to test the practicability of adding miticides to the standard DDT spray used in spruce budworm control. We decided to add enough Genite 923 either to control the mites or to prevent increase in mite populations of proportions that would result in heavy damage to Douglas-fir foliage. Collections were planned in areas previously sprayed to determine the population densities of mites for comparison with those in unsprayed forests.

Spraying was timed to obtain effective control of spruce budworm when 60 percent of the larvae were in the fifth and sixth instars. Mortality of budworm larvae ranged from 94.6 to 99.6 percent on individual spray blocks, and averaged 97.7 percent for the entire study area.

Periodic examinations made between the last day of spraying (July 2) and the completion of sampling (September 2) revealed no significant changes in spruce spider mite populations on any of the spray or check plots. Natural populations of mites in check plots approximated 0.03 mite per linear inch of foliage, which was roughly the same as in sprayed areas. Since damaging populations of mites have appeared the year following spraying, we feel that analysis in 1959 will reveal whether addition of a miticide has actually produced a controlling influence.

We also made collections to determine densities of spider mite population on Douglas-fir forests sprayed in 1956 and 1957 for control of the spruce budworm and to compare these populations with those on adjacent unsprayed forests.



The Henderson and McBurnie mite brushing machine.

Freshly cut 15-inch tips of Douglas-fir were taken immediately to a field laboratory where a mite brushing machine removed mites from the foliage and deposited them on a glass disk. Each disk was examined with a binocular microscope, and the number of mites counted on them was expressed in terms of linear inches of foliage.

No appreciable mite populations were found during this study outside of areas sprayed in 1956 and 1957 for spruce budworm control, as indicated in the following tabulation:

Area	Number of mites and mite eggs per linear inch of foliage	
	Sprayed 1956	Unsprayed (check)
Lewis and Clark National Forest	2.9	0.003
Helena National Forest	.8	.010
	Sprayed 1957	Unsprayed (check)
Deerlodge National Forest	0.7	0.003
Beaverhead National Forest	.7	.063
Yellowstone National Park	1.3	.008
Lewis and Clark National Forest	3.4	.045

Analyses of these data showed that spider mite populations were significantly higher on samples from 1957 spruce budworm control units than they were on samples from adjacent unsprayed forests. At the 5-percent level there was no significant difference between spider mite populations on samples from units sprayed in 1956 and samples from adjacent unsprayed forests.

Spruce spider mites trapped on an adhesive-coated glass disk are counted with a binocular microscope.

Predaceous mites of the families Phytoseiidae and Trombidiidae were found most commonly associated with populations of the spruce mite. They were more abundant on sprayed areas than on unsprayed forests. Under natural conditions these predaceous mites, as well as several insect species, are the most effective predators in preventing population buildups of the spider mite. It appears that these predators were killed by DDT spraying in 1956 to control spruce budworm infestations. As a result, spruce spider mite populations increased to epidemic proportions.

On areas sprayed both in 1956 and 1957, populations of the spruce spider mite were from 20 to 30 times as large as predaceous mite populations; however, on unsprayed areas spider mite and predaceous mite populations were about equal. On unsprayed areas where biological balances were not upset, predaceous mite populations kept spruce spider mite populations at endemic level.

We do not know certainly how many spruce spider mites on any area, tree, or unit of foliage constitute an epidemic. However, when the number of mites on a 15-inch branch sample reaches 0.1 per linear inch of foliage, damage to the host tree is visible and can be seen by aerial survey personnel at one-half mile distance; heavier damage is visible for three-quarters of a mile.

Examination during 1958 of areas showing heavy foliar injury in 1957 revealed that mite populations had decreased significantly. Foliage produced in 1958 showed some mite feeding, but was only lightly injured. We saw no mortality resulting from heavy feeding in 1957, and infested stands appeared to be recovering satisfactorily.

SURVEYS

The annual insect detection and appraisal survey program in our territory was strenuous during 1958. The cooperation of other Federal, State, and private land managers made it possible to cover almost all of the important forested areas. Station entomologists collected and coordinated a large volume of widely varied forest insect information within the area. The increase in numbers and intensity of outbreaks in the Intermountain and northern Rocky Mountain States during this season was general. Decrease in intensity was noted in only a few areas.

As in 1957, the spruce budworm was the most prominent insect pest in Montana and Idaho on approximately 4 million acres of Douglas-fir and true fir. The infested acreage in Montana was only slightly greater than in 1957, but in southern Idaho the infested area has increased noticeably each year since 1952. As might be expected, trends in separate infestations are upward in several areas, static in some, and downward in a very few.

The pine butterfly, Neophasia menapia Feld., infested approximately 50,000 acres of ponderosa pine in southern Idaho. While the outbreak of this species has not reached epidemic intensity, the trend of populations of this tree killer is being watched carefully. A relatively high population of parasites seemed to be present at this stage of development of an outbreak.

Plans for an aerial spray project against Douglas-fir tussock moth in Owyhee County, Idaho, late in 1957 were canceled when presence of a virus disease affecting the larvae was noted. Events in 1958 justified the decision to forego spraying since virus disease and other biological agents practically eliminated the outbreak.

During the 3 years prior to 1958, western larch had suffered defoliation by larch budmoth, a larch looper, and two species of sawflies in western Montana, northern Idaho, and northeastern Washington. During 1958, populations of these four insects practically disappeared. The larch casebearer, first reported near St. Maries, Idaho, in 1957, is now known to be present over 110 square miles in northern Idaho and northeastern Washington. Major defoliation still occurs on 15,000 acres around St. Maries.

For several years an increase in populations of mountain pine beetle in lodgepole pine has been recorded, especially in Utah, southern Idaho, and western Wyoming. This trend continues with numerous infestations developing on national forests, the Grand Teton National Park, and private lands adjacent to these areas. For several years the mountain pine beetle has actively attacked ponderosa pine in Nevada near Lake Tahoe, and this past summer a new outbreak in second-growth ponderosa pine was discovered on the Boise National Forest.

Outbreaks of Engelmann spruce beetle appeared in 1958 over widespread areas in Utah and southern Idaho. The most serious epidemic covers about 100 square miles of spruce type located in Utah where the Wasatch, Uinta, and Ashley National Forests join. More limited, but still serious, conditions were observed on the Manti-LaSal and Dixie National Forests in Utah and on the Payette National Forest in southern Idaho. Older infestations in Montana and Wyoming have been reduced by control, but further effort will be required to effect a return to endemic conditions.

Douglas-fir beetle populations displayed a distinct upward trend this season after several years at a relatively low level. This tendency was noted generally throughout the station's territory.

For the first time since 1952, heavy populations of the lodgepole needle miner were present on the Sawtooth and Targhee National Forests in Idaho.

It is evident that forest insects could be an increasingly serious factor in the management of forest stands in the Intermountain and northern Rocky Mountain States during the next few years if present trends continue.

During 1959 we shall experience another busy season of surveys because of the present high level of outbreaks. We expect that forest managers engaged in suppressing outbreaks will call on Intermountain Station entomologists for technical assistance as they did during 1958. Research studies on the pests highlighted in this report will be continued, as will those on other pests, in our effort to develop better methods of preventing outbreaks and of reducing excessive losses.

FOREST FIRE RESEARCH

Forest fire research at Intermountain Station is designed to perform two broad functions: first, to conduct basic and applied research on assigned fire problems of nationwide significance; and, second, to conduct specialized regional research on fire problems peculiar to the Intermountain West and Alaska, where some 335 million acres of forest and watershed lands require protection from fire. The chief specific objective of this program is to produce research results that may prevent wildfires; reduce the number of large "blowup" fires; effect safe, economical, and efficient methods of fire control; and enable use of controlled fire as an aid in natural resource management. Achievements of fire research in 1958 are a substantial step towards realizing this objective.

NORTHERN FOREST FIRE LABORATORY

1958 marked realization of a long planned program to develop a forest fire laboratory in the Intermountain region. The second session of the 85th Congress appropriated $900,000 to the Forest Service for constructing and equipping a forest fire laboratory at Missoula. This new unit, officially named the Northern Forest Fire Laboratory, will greatly facilitate research needed in a stepped-up attack on the major fire problems listed above.

The Northern Forest Fire Laboratory will be erected adjacent to the County Airport directly contiguous to the Region 1 Aerial Fire Depot. During the summer of 1958, contracts were let to architectural and engineering firms to design the laboratory. Work on the utilities, road, and airplane taxiway systems was also started. We expect construction of the building to start early in the spring of 1959.

Designing this laboratory has been a comprehensive research project in itself. Many of its facilities have never before been incorporated in a research laboratory. The main building will include physics, chemistry, instrument, photographic, meteorological, and statistical laboratories; a combined library and conference room; drafting room; and offices for fire research personnel. The wing for combustion studies will provide facilities for fire experiments under controlled atmospheric conditions. This wing will contain a 66-foot-high fire experiment chamber, two wind tunnels, a fire behavior viewing room, and a fuels laboratory. Closed circuit television will make possible the viewing and recording of combustion experiments. Another wing will house shops and facilities for fire equipment research.

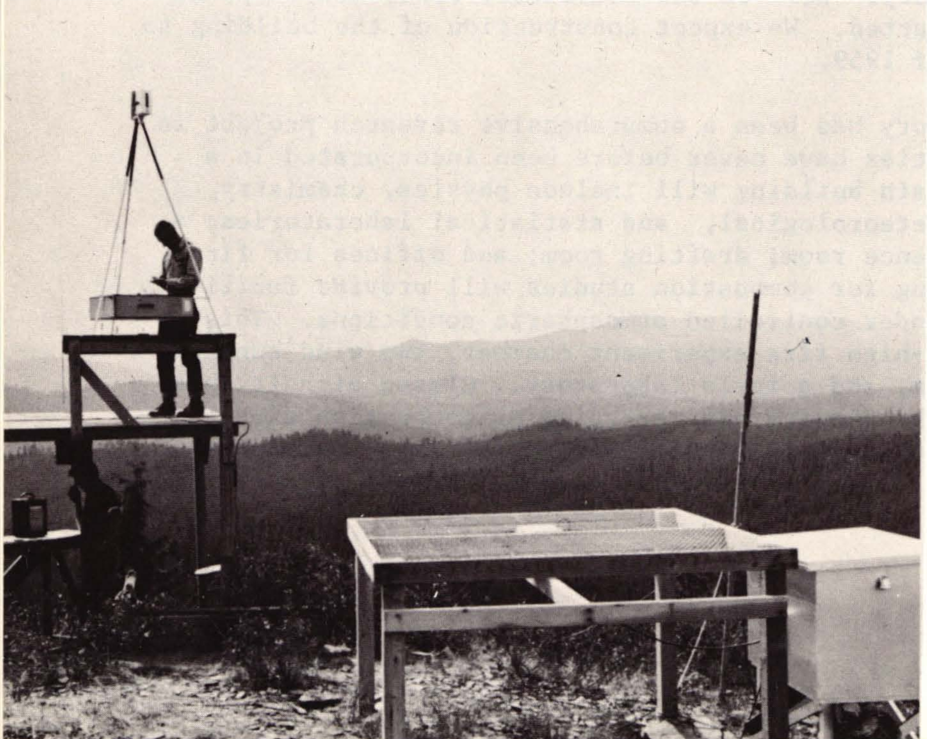
These new facilities will make possible a truly effective program of basic research on combustion processes, fire environment, and the physics and chemistry of fire extinguishment. We shall be able to approach critical problems in fire prevention, detection, and suppression, and in prescribed use of fire with new opportunity for successful development of basic knowledge, useful techniques, and effective tools.

PROJECT SKYFIRE

Current research on the lightning fire problem is being concentrated on thunderstorm electrification and the possibilities for modifying the electrical characteristics of cumulus clouds by seeding. The 1957 Skyfire experiments showed that cumulus clouds could be modified by silver iodide seeding, but did not provide data on possible electrical effects of seeding operations. Accordingly, in 1958 we began field experiments to learn how lightning might be affected when cumulus cloud buildups are seeded by either ground-based or airborne silver iodide generators.

Lolo Experiments

We instrumented an experimental area on the Lolo National Forest for measurement of lightning and atmospheric electricity factors in seeded and unseeded clouds. Equipment included 3 electric field meters and recorders for measurement of electric field changes, 2 experimental lightning counters, a mobile radar unit, 5 time-lapse photography stations, pilot balloons, 30 ground-based cloud-seeding generators, and an instrumented aircraft. Observers at mountaintop stations made detailed observations of weather and atmospheric factors.



Electric field meter and full sky time-lapse camera used on Project Skyfire lightning fire research area in Lolo National Forest.

After establishing specifications for the cloud and lightning factors that would constitute an operations day, we determined whether any given day would qualify for experimental operations on the basis of special forecasts by the U. S. Weather Bureau. By a randomizing technique we selected days for operating or not operating the cloud-seeding generators. This procedure gave us comparable pairs of seeded and unseeded situations that could be analyzed to determine the effects of seeding on electrical and lightning factors. The 22 seeding operations carried out during July, August, and September produced 8 pairs of seeded and unseeded situations that met specifications for analyses.

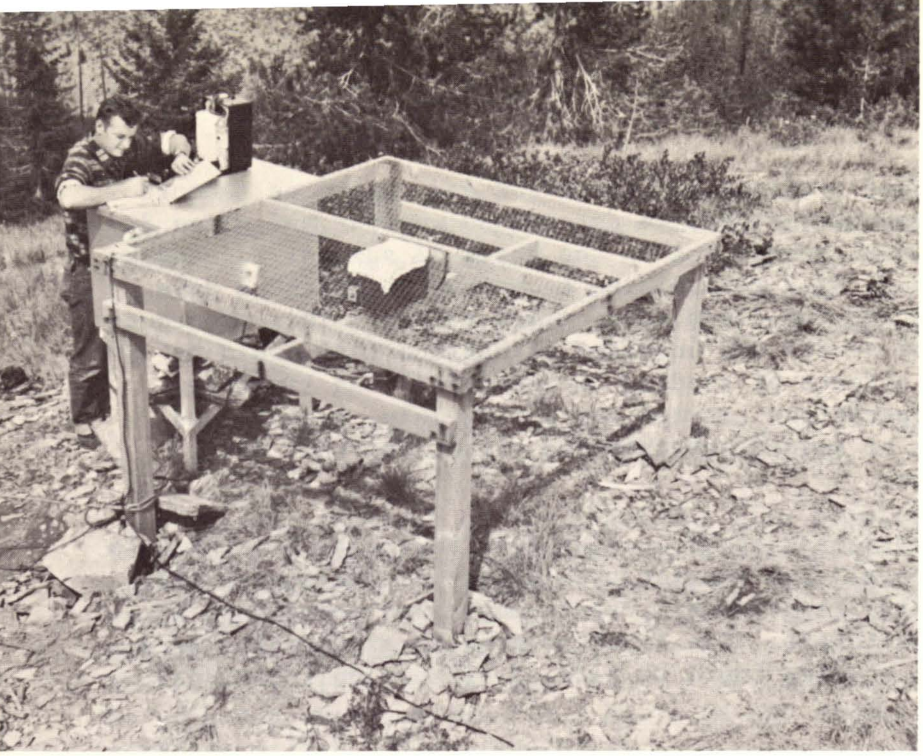
We also did some experimental cloud seeding from aircraft over the Lolo National Forest research area. Two ram-jet type silver iodide generators were modified to meet Skyfire experimental requirements and mounted on a Forest Service Cessna 180 aircraft. The airborne seeding experiments were conducted so that specific studies could be made of effects on individual clouds.

University of Arizona Experiments

The Institute of Atmospheric Physics at the University of Arizona is experimenting with seeding effects on cumulus clouds in the Santa Catalina Mountains near Tucson. In 1958, the station arranged a cooperative agreement with the university so that observation and measurement of electrical effects could be included in the experimental seeding operations. Electric field meters and a lightning counter were installed in the Santa Catalina experimental area on the Coronado National Forest. Two observers stationed in the area made lightning counts and recorded other data needed in evaluating results of cloud seeding. All seeding was carried out with an airborne generator. Randomization was used to select days for seeding operations.

Results of Cloud Seeding

Analyses of results of the 1958 experiments in Montana and Arizona are not yet completed. Preliminary analysis of Skyfire experiments on the Lolo National Forest indicates that under some situations lightning may be initiated and the frequency of cloud-to-ground lightning strikes increased by some cloud-seeding techniques. These preliminary results also suggest that true overseeding (mass conversion of supercooled water droplets to ice) cannot be accomplished over a broad area with present equipment or seeding techniques. If we plan to seed thunderclouds in order to prevent lightning, overseeding appears to be necessary. The full effect of cloud seeding on lightning fire occurrence involves many factors including precipitation, duration and intensity of storms, and fire-danger rating before and after the storm. Definite conclusions regarding the effects of weather modification on the lightning fire problem must await results of the analyses under way and the information to come from future experiments.



Electric field meter is used by Project Skyfire to record lightning strikes and other atmospheric electricity factors during cloud-seeding experiments.

Skyfire research in 1958 provided an important test of new methods for conducting weather modification experiments involving evaluations of atmospheric electricity. Electrical field meters used in conjunction with radar, photographic stations, measurements from aircraft, observations from mountaintop stations and special weather analysis procedures are an important means for gaining basic knowledge on thunderstorm electrification and on some of the specific effects of cloud seeding. Equipment and experimental techniques for this research have now passed preliminary tests and are ready for use in the more intensive studies ahead.

Cloud and Lightning Survey

Techniques for cloud and lightning survey developed by Project Skyfire were tested on a pilot operation basis during the 1958 fire season. We prepared a cloud and lightning survey handbook to guide lookout firemen who made daily observations at 25 stations in Montana, Idaho, Oregon, Washington, and Wyoming. The 1958 tests were preliminary to full operational development of a system of cloud and lightning observations that will become a regular part of fire lookout duties at selected stations.

FIRE CONTROL RESEARCH

Fire-Danger Rating System

A major activity in 1958 was extension of fire-danger rating activities to western lands protected by the Bureau of Land Management of the U. S. Department of the Interior. This bureau assigned a full-time fire research liaison officer to Missoula to assist in this program. Working in cooperation with our research staff, he established experimental fire-danger rating systems on 34 Bureau of Land Management districts in 10 western states. As an interim measure to establish fire-danger rating operations and to obtain experimental data, the regional systems already developed by the California, Pacific Northwest, Rocky Mountain, and Intermountain Experiment Stations were used on a trial basis. We believe that these four systems of fire-danger rating can satisfactorily serve the Bureau of Land Management districts on this trial basis until they can be replaced by a single national or western system. Meanwhile, we can gather and correlate many valuable fire-danger rating data for the Bureau of Land Management districts that will aid both fire control and fire research programs.

Besides this work with the Bureau of Land Management, our staff carried forward a variety of individual and cooperative projects. In cooperation with Regions 1 and 4 of the Forest Service, the U. S. Weather Bureau, and other Federal, State, and private agencies, we continued to help in planning the location of fire-weather stations, and in operation of fire-danger rating systems. We assisted a graduate student project at Montana State University that is directed toward developing a method for rating fire season severity. Our staff gave technical supervision for manufacturing fuel moisture sticks used by fire control agencies throughout the western United States. These sticks are manufactured at the Forest Service warehouse in Spokane. Quality control of these sticks was field tested at the Priest River Experimental Forest. The amount of erosion (loss of wood) due to weathering was studied in a moderate climate at Priest River Experimental Forest and in a severe climate at Desert Experimental Range.

Fuel moisture research at both the Priest River and Boise Basin Experimental Forests provides basic data for design and use of future fire-danger rating systems. Rate and amount of moisture change are measured in various sizes of fuel samples exposed to the different weather conditions at these two forests. Field data from these experiments will provide design criteria for fully controlled experiments on fuel moisture that can be conducted soon in the Northern Forest Fire Laboratory. Our goal is to learn how to measure, predict, and interpret fuel moisture factors in rating forest and range flammability.

Alaska Fire Research Project

During the 1958 fire season in Alaska the Bureau of Land Management continued operation of 10 experimental fire-weather stations in conjunction with tests of the Model 8 burning index meter. Portable fire-weather stations also were used in field studies of fire-danger factors at seven fires. These field studies at fire sites provided the best data obtained to date on some factors that influence flammability under Alaska's fuel and weather conditions.

Two members of the fire research staff in company with the Bureau of Land Management fire research liaison officer visited Alaska after the 1958 fire season to help plan research activities. In addition, members of the Bureau of Land Management staff in Alaska came to Missoula to help analyze fire problems and to review fire data assembled in 1958.

An important innovation in 1958 was the use of an IBM system for recording and analyzing fire data from Alaska. Individual fire reports and fire-weather data were punched on cards. These data are being analyzed statistically as part of the preparation of a fire problem analysis for Alaska. We are developing research work plans for fire-danger rating, fuels and fire behavior, fire detection, and lightning fire control.

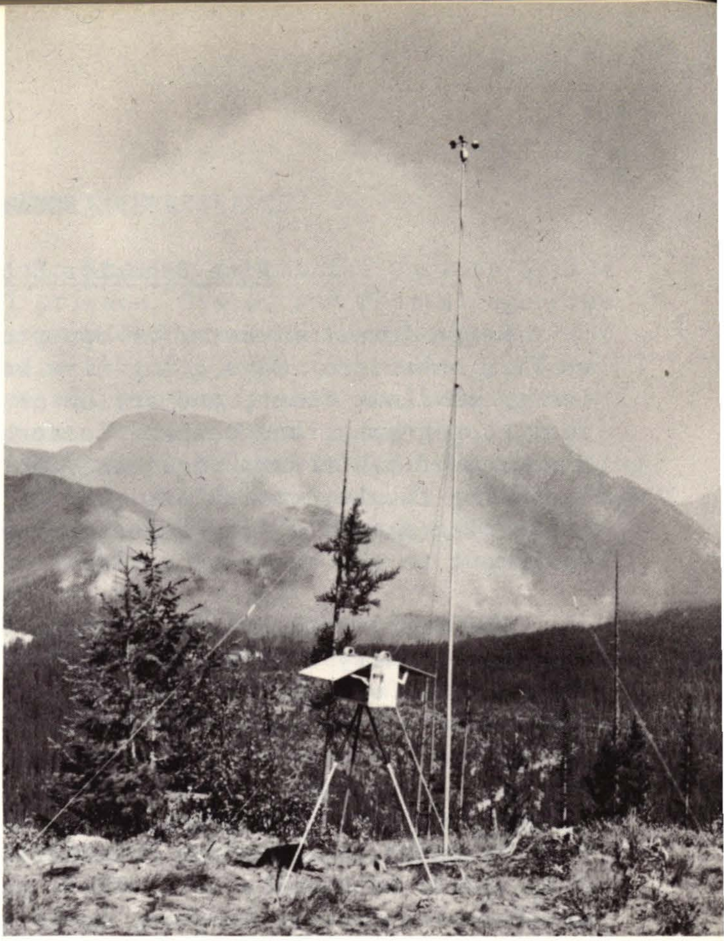
FIRE EQUIPMENT RESEARCH

Fire-Weather Equipment

We brought several items of fire-weather equipment closer to final development in 1958. Development of the "Ranger's Weather Kit" is now complete. This belt-type weather kit enables a man to measure temperature, relative humidity, and wind velocity at any place he can walk to. The portable fire-weather station developed by this division underwent field tests at 22 locations, including several in Alaska. Final specifications for this new unit will be ready early in 1959. Tests of the prototype unit showed that it provides a convenient means for obtaining accurate measurements of fuel moisture, temperature, relative humidity, wind velocity, and precipitation with mobile equipment at sites of fires and other field projects where weather information is needed.

We have developed pilot models for two new types of automatic recording fire-weather stations. One type records meteorological instrument readings photographically. Preliminary field tests last fire season showed that photographic recording of weather measurements can be made automatically at field sites with relatively inexpensive equipment. Redesign of this unit to incorporate several improvements in operation is nearly complete. A second type of automatic weather station employs a multiphase battery-powered chart recorder. The pilot model will be ready for laboratory and field tests in 1959. This type of station will permit continuous automatic measurement and recording of fire-weather factors for periods as long as one week.

Portable fire-weather station developed by Division of Forest Fire Research in use at the scene of the Coal Creek fire, Glacier National Park.



Advanced Equipment Research

Much of the advanced equipment research in 1958 was centered on items to be used in the new forest fire laboratory. We prepared preliminary specifications for a fuel measurement system including a controlled temperature-humidity chamber with capabilities for creating diurnal changes, electric drying ovens, and weighing apparatus for fuel beds. Field tests of an experimental lightning counter indicated methods for improving design of circuits. Other advanced equipment research included continued work with mobile radar, experimenting with electric field meters, and further investigations of the design of airborne silver iodide generators and airborne instruments for measuring atmospheric stability above fires.

FIRE BEHAVIOR RESEARCH

Fire Behavior Studies on Going Fires

Large forest fires offer opportunity to obtain fundamental information on fire behavior. On a going fire we can study rate of spread, characteristics of flame front, and action of the convection column in relation to fuel, topography, and weather factors. However, the use of large fires as a source of basic data requires development of equipment and techniques for measuring the key variables. During 1958 we started developing plans for organizing a mobile fire research team that could move rapidly with necessary equipment to the scene of a fire.

The Coal Creek Fire in Glacier National Park (August 1958) gave excellent opportunity to test this method of gathering research information. Prompt relay of information about this fire to the forest fire research staff at Missoula enabled a 6-man team to be dispatched to the scene fast enough for measurement and observation of fire behavior during the second, and most important, period of major fire activity. Observations and measurements were continued through the fourth day of fire activity. This research team included two research foresters, two research meteorologists, a forestry aid, and an airplane pilot. Their equipment included a Cessna 180 aircraft instrumented for temperature, humidity, and pressure measurements; two portable fire-weather stations, four belt weather kits, four time-lapse motion picture cameras, three FM portable radios, and miscellaneous gear. This experimental operation showed that such a team equipped for both aerial and ground measurement of fire behavior factors can gather important basic data needed in our research program.

Fire Behavior Training

The first National Fire Behavior Training School was held at Missoula during March and April. Intermountain Forest and Range Experiment Station and Region 1 were hosts for this school. Trainees from all regions of the United States attended the 5-week course, which was conducted at the Region 1 Smokejumper Center. Much of the training program presented results of fire research during the last several years. Intermountain Station's fire research staff, in cooperation with men from other regions, stations, and cooperating agencies, prepared special material and equipment for the fire behavior training course. Success of this training school is attested by the scheduling of a second servicewide Fire Behavior Training School in January and February 1959 in Alexandria, Louisiana. Its instructing staff includes one research forester from Intermountain Station.

COOPERATION IN FOREST FIRE RESEARCH

Forest fire research at Intermountain Station is carried on with active participation and assistance of several private, State, and Federal agencies. This last year the U. S. Weather Bureau provided personnel and equipment for Project Skyfire and gave technical service for all projects. Munitalp Foundation, Inc., gave general assistance on all projects; this included provision of personnel, equipment, and funds for Project Skyfire and for fire behavior research. The Bureau of Land Management helped in fire-danger rating research in Alaska and western states, gave general assistance in planning new fire research projects and in fire problem analysis, and provided a fire research liaison officer.

National Park Service of the Department of the Interior operated a Project Skyfire station and helped in fire-danger rating research in Montana, Wyoming, and Utah. National Forest Administration gave general assistance on all fire research projects, and California State Division of Forestry provided certain equipment and technical assistance for Project Skyfire.

Another group of important cooperators was four western universities. University of Washington provided meteorological equipment for Project Skyfire. University of Arizona performed contract research on effects of cloud seeding on lightning occurrence. University of Idaho helped in research on logging slash. Montana State University gave general assistance on fire research projects, helped in training student assistants, and sponsored graduate student research projects.

FOREST ECONOMICS RESEARCH

The Division of Forest Economics Research carries on two major projects--the Forest Survey of the Rocky Mountain States and research studies in forest economics. Both projects were in full operation during 1958. The Forest Survey inventoried approximately 8-1/4 million acres of forest land in Colorado, Wyoming, and Montana. The Forest Economics section progressed well in its analysis of timber potentials in the Clark Fork area of western Montana and the north slope of the Uinta mountains in northern Utah.

FOREST SURVEY

The Forest Survey program includes the initial inventory of forest areas not yet covered by the national survey and periodic reinventory (at 10- to 12-year intervals) to keep forest resource information up to date. Inasmuch as nearly three-fourths of the commercial forest area in the Rocky Mountain States is in national forests, both the initial and reinventory programs are closely coordinated with the timber management surveys of the national forests.

The initial forest survey has been completed in Montana and Idaho and is under way in Colorado and Wyoming. During the 1958 field season sample plot work was completed on approximately 6 million acres of forest land in Colorado, principally on and adjacent to the Pike, San Isabel, and Arapaho National Forests. Some 3 million acres of this was commercial forest land. The remainder was noncommercial stands of pinyon-jumiper, aspen, or brushy vegetation valued chiefly for grazing and erosion control. Present plans provide for completion of the survey field work in Colorado in 1959.

In Wyoming, field work was completed on the Bighorn National Forest covering 826,000 acres of forest land; this included 700,000 acres of commercial forest.

Field work on the reinventory of western Montana, under way during the last 3 years, was completed in 1958. Approximately 1.3 million acres of commercial forest land was inventoried by national forest and Forest Survey crews during the field season. Data are now being tabulated to provide the national forests and Intermountain Station with new information on the forest resources of western Montana.

In cooperation with Region 1, we used a helicopter on the inventory of isolated portions of the Flathead National Forest. This machine, a Bell Ranger Model J-2, was used to transport field crews to plot locations in remote areas that otherwise would have required pack trips. Preliminary cost records indicate that use of this model helicopter can be justified only on the most remote areas or when the time saved is more important than cost.

In 1959 we shall start the second reinventory of northern Idaho. The first year's work will be a pilot study to test proposed changes in Forest Survey techniques.

Timber Cut

Surveys to determine the 1957 production of lumber and primary forest products in Wyoming and Colorado were conducted in cooperation with the Rocky Mountain Forest and Range Experiment Station and the Bureau of the Census. Reports on the findings are being prepared by the Rocky Mountain Station. Preliminary data for Wyoming indicate a lumber production of nearly 109 million board feet in 1957. Lodgepole pine, spruce, and ponderosa pine were the principal species, and accounted for more than 95 percent of the total cut.

Annual surveys of the production of commercial poles in northeastern Washington, northern Idaho, and Montana have been made in cooperation with the Rocky Mountain Pole and Treating Association since 1947. The survey made in 1958 reported production of 509,000 poles in 1957. This is 12 percent below the 1956 output, but is above the 10-year average of about 478,000 poles.

Aerial Photo Interpretation

Increasing interest in the use of aerial photos in many forestry programs has brought Intermountain Station a number of requests to conduct training seminars for photo interpreters. Not all these requests could be granted, but four training seminars were held this year, with a total of 75 foresters in attendance.

Our studies of requirements for training photo interpreters indicate that 40 to 80 hours of directed intensive practice are needed to train foresters to estimate timber volumes satisfactorily from aerial photos. The 6 to 8 hours' training usually given in school courses at best can serve only as an introduction.

Estimates of timber volume on five tracts by six foresters indicate that volume can be estimated from photo measurements at ±25 percent of the 100 percent cruise volume two times in three on 40-acre tracts and ±10 percent two times in three on 200-acre tracts. This degree of accuracy in estimating is comparable to that accepted on ground cruises, but the estimate made by photogrammetric means costs only one-third to one-half as much as a ground cruise.

We made pilot studies for the station's Divisions of Watershed Management and Range Management Research to explore possibility of the use of photo interpretation in their research. Several watersheds proposed for research projects were studied in detail on aerial photos and were rated for relative value for research purposes. Although the photo results have not yet been ground checked, it appears that use of aerial photos can save several days of ground survey.

We prepared stereograms for the Division of Range Management Research illustrating various kinds and degrees of stocking on the Benmore Experimental Range. Study of these photos may provide criteria for classifying types of cover and stocking on range lands.

FOREST ECONOMIC STUDIES

Two studies mentioned in the 1957 Annual Report have virtually been completed and should be published early in 1959. Resource Base for Expanded Markets in the Mountain States describes generally the commercial opportunity inherent in the mineral, agricultural, water, climatic, and other resources of the Mountain States. This analysis indicates that the region has the ingredients needed for a continuing healthy growth, which in turn suggests an expanding local market for forest products. This study also lays necessary groundwork for studies in related range and watershed economics.

Production-Distribution Trends and Freight Rates as They Affect Mountain States Lumber Production, now being reviewed, is based on lumber distribution data and Interstate Commerce Commission statistics. This reconnaissance type study touches on four general subjects: (1) where Mountain States lumber is now marketed; (2) production and distribution trends that have influenced the lumber industry in this region; (3) the significance of freight rates to the lumber marketing; and (4) areas that need additional study to encourage development and improve lumber marketing.

Principal projects of the economics studies staff in 1958 were the Clark Fork study in Montana and the North Slope study in Utah. Both studies deal with the timber resource and attempt to carry forward the analysis begun in the Timber Resource Review. The Review established long range timber production objectives for the Nation. The first need is to determine what these objectives require in the way of timber output from each forest locality. Second, and perhaps more important, is to determine the management task that the local objectives describe. For the 5-million-acre Clark Fork Unit, our study attempts to answer two broad questions: (1) How much industry, and of what kinds, can the timber in this unit support? (2) What kind and how much management will be required to sustain the timber production needed to feed these industries?

During 1958 we completed a comprehensive survey of the Clark Fork lumber industry and the first reinventory of the Clark Fork timber resource. A special dwarfmistletoe survey involving more than 2,000 sample plots in the Clark Fork Unit was conducted cooperatively for this study by the station's Division of Forest Disease Research and Region 1. Procedures have been designed for analyzing Forest Survey plot and area data in the development of timber management programs for this unit. We are therefore prepared to move into the final phases of the Clark Fork study in 1959.

The North Slope Unit is a 750,000-acre area along the northern boundary of Utah. The commercial forest in this unit is largely lodgepole pine of medium and poor site. Although hundreds of thousands of railroad ties were taken from this area in the late 1800's, relatively little cutting has been done in the last several decades. Actually, this unit is essentially undeveloped. Recent interest in the lodgepole timber here for both lumber and pulp makes it necessary to prepare a development program. This task raises a confusing galaxy of questions--all important, all separate, but still so interrelated that it is difficult to know where to begin. Here are some of these questions:

> Which areas should be logged first because of their age and vulnerability to attack by insects and disease?
>
> Which of the existing young stands will benefit from cultural work? What is the nature of the silviculture needed? How much will it cost? Is it economically feasible?
>
> Which of the young stands are so badly stagnated or infected with dwarfmistletoe that we should clear cut them and encourage regeneration?
>
> What level of cut do the nature and distribution of existing stands permit? What is the character of this cut from the standpoint of species and tree size?
>
> What roads are required for the near future to permit logging the stands that need logging, and managing the stands that need managing? How much will they cost?
>
> What kind of industrial development is desirable to make best use of the timber available? How far can industries afford to go in utilizing that timber?

Answering the questions alone will not solve the problem. The answers must be resolved into a coherent program that spells out rather specifically the actions to be taken and the costs involved.

The first major step in this study has been to make a complete, detailed inventory of the timber in the North Slope Unit. Region 4 and Intermountain Station are cooperating in a type mapping project considerably more intensive than any undertaken heretofore. Classification schemes have been revised and additional information collected to provide inventory statistics that describe management needs and problems more satisfactorily than present survey statistics.

Both the Clark Fork and North Slope studies require an almost complete pooling of talents. In addition to the Division of Forest Economics and the two Forest Service regions, the Divisions of Forest Management Research, Insect Research, Disease Research, and Utilization Research of Intermountain Station are contributing counsel and help. Not the least of the objectives of these two projects is to develop better tools for timber management planning. It is already obvious that certain modifications could make the basic inventory information more useful.

FOREST UTILIZATION RESEARCH

Utilization is an integral and important part of the Nation's total forestry program. Unless forest products can be efficiently harvested and used to supply man's important economic needs, there is little justification for expressing much alarm about our declining resource or for setting up long-range goals for forestry. This is not to say that timber is the sole or even the most important product of the forest; but where commercial crops are being grown and are ready for harvest, full utilization is an immediate and dynamic challenge. The general purpose of this division is to encourage use of the most modern technology in the task of timber utilization.

Specifically this division is expected:

1. To determine the regional utilization research needs and try to have these needs met by research at the Forest Products Laboratory and other wood research centers.

2. To assist in the interpretation of research results in the light of regional needs and to encourage their early application.

3. To conduct research that is within the capacity of the division and to cooperate in studies that are best made in the field.

Forest industries have just experienced one of their most hectic years. At the start of 1958, prices of lumber, paper, plywood, and other products touched their lowest point in recent years. At the same time, retail and wholesale inventories were at record highs. Many sawmills closed down, and all talk of forest industry expansion temporarily ceased. 1958 promised to be a year of widespread industrial belt-tightening and, as the year opened, it appeared that the few mills caught in the middle of major expansion programs had made bad guesses.

Fortunately the picture quickly changed. By midyear the market was as firm as it had been a year earlier. Inventories were depleted and prices again rose. Expansion programs once more moved into high gear. However, in the year's final quarter a secondary slump took some of the power out of the upward drive. Production was maintained at peak levels at the end of 1958 mainly in the hope for a booming 1959.

Part of the program in forest utilization research is so closely related to short-term markets and industrial attitudes that these factors cannot be ignored. Motivation for doing research and, more specifically, for applying results of research is geared directly to short-term economics. However, the long-term general upward trend has made it possible to forge ahead with several significant industrial developments, the product of earlier research. Several of these are noted below.

Some of the region's sawmills have improved their utilization by installing barkers and chippers. Operations of new pulp mills in Missoula, Montana, and Wallula, Washington, plus the increased capacity of the mill at Lewiston, Idaho, have made possible the further use of sawmill leftovers. Actually, during the period of lowest lumber prices in 1958, the profit for some operators in selling chips was equal to or greater than their profit from finished lumber. The opportunities and promise of additional pulp mills means that this trend toward improved utilization will continue.

The improvement in utilization was by no means restricted to sawmills. The plywood mill at Polson, Montana, installed a sander and as a result now produces finished plywood panels. A new lathe for producing green veneer was installed at Idaho Falls. Several new laminating operations were opened during the year, including a quick assembly, continuous beam laminator at Lewiston, Idaho.

Regionwide, industry is moving in the direction of manufacturing finished products--consumer goods--rather than continuing to produce only factory raw materials. We have anticipated this important change for many years. Such products as paper-overlaid sheathing panels, end- and edge-glued lumber suitable for direct installation as decorative paneling, prefabricated and precut trusses, and a host of lesser commodities exemplify this growing trend.

One mill now utilizes a portion of the bark as a treated soil conditioner. Another is veneering western larch long butts, the short pieces of high grade material (but with rotten centers) cut off of saw logs. Still another mill cuts small clear pieces 1"x1"x8" for door cores and is baling planer shavings for farm use.

All these industrial developments mean that utilization is making solid progress--and in the direction we like: toward full use of the available resource. Likewise, utilization research has made new achievements that appear to have lasting significance.

Our divisional research program has developed along specific projects within four distinct fields:

Timber growth
Timber harvesting
Timber processing
Timber utilization.

One important project related to timber growth has been the continuing study of effects of spiral grain in poles. Field observations at Newport, Washington, were completed this year, and the poles have been sectioned for microexamination. A similar study is still under way at Libby, Montana. General conclusions are that poles having left-hand spiral continue to twist badly even after installation. Oddly, and for no definitely known reason, poles having equally severe right-hand twist perform satisfactorily. We hope that microanalysis of test specimens will throw some light on this anomaly. Forest management research feels that growth rate and sudden changes in growth rate are associated with spirality and fibril angle. To test this hypothesis, the Missoula Research Center has started a study of this association in western larch.

Logging technique looms as a major regional problem in the years immediately ahead. To better crystallize our philosophy and define responsibilities, this division has completed a problem analysis that points out the joint responsibilities of land managers, loggers, and equipment manufacturers; the magnitude of the job ahead; and the significance of the results of their operations. This analysis identifies several specific logging problems and suggests solutions.

In 1958, Intermountain Station spearheaded a series of small sawmill clinics in cooperation with the Forest Products Laboratory, National Forest Resource Management, state foresters, schools, and industry. These clinics are gradually improving the general quality of our 600 small sawmills, and long-range results are bound to be beneficial.

This station is cooperating with the Forest Products Laboratory in nationwide studies of temperatures at critical points in frame dwellings and of moisture contents in certain other types of building.

The station continues its cooperation with the National Log Grade Committee. This year we have given special assistance to the ponderosa pine working group by providing data.

1959 promises to be a busy year. All indications are that the forest industries will renew their programs for modernization and expansion; construction will bring new demands on design criteria; and new wood-using industries will be established. The Division of Forest Utilization Research has assigned a technologist to the Missoula Research Center to help meet research needs in that area.

RANGE MANAGEMENT RESEARCH

TREND IN CONDITION OF HIGH-ELEVATION RANGE-WATERSHEDS OF THE BOISE RIVER

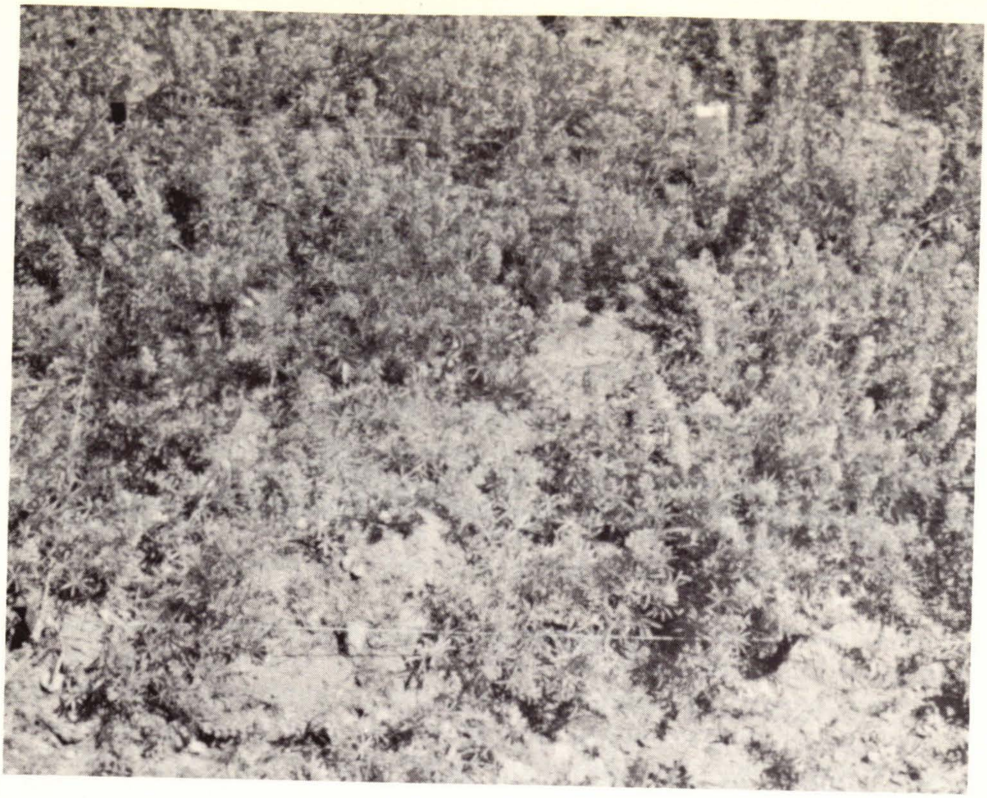
General deterioration of high-elevation sheep ranges of the Boise River watershed is indicated by the 25-year record of permanent plots at 7,500-7,900 feet elevation. In four out of five study areas the trend in condition was found to be downward; palatable perennial grasses were being replaced by less palatable forbs (weeds) and continuing erosion.

The plots were established in 1930 in the drainage of the South Fork of the Boise River. Trends at the lower elevations (3,900-5,100 feet) and general features of the topography, soils, and vegetation, were discussed briefly in the 1957 Annual Report.

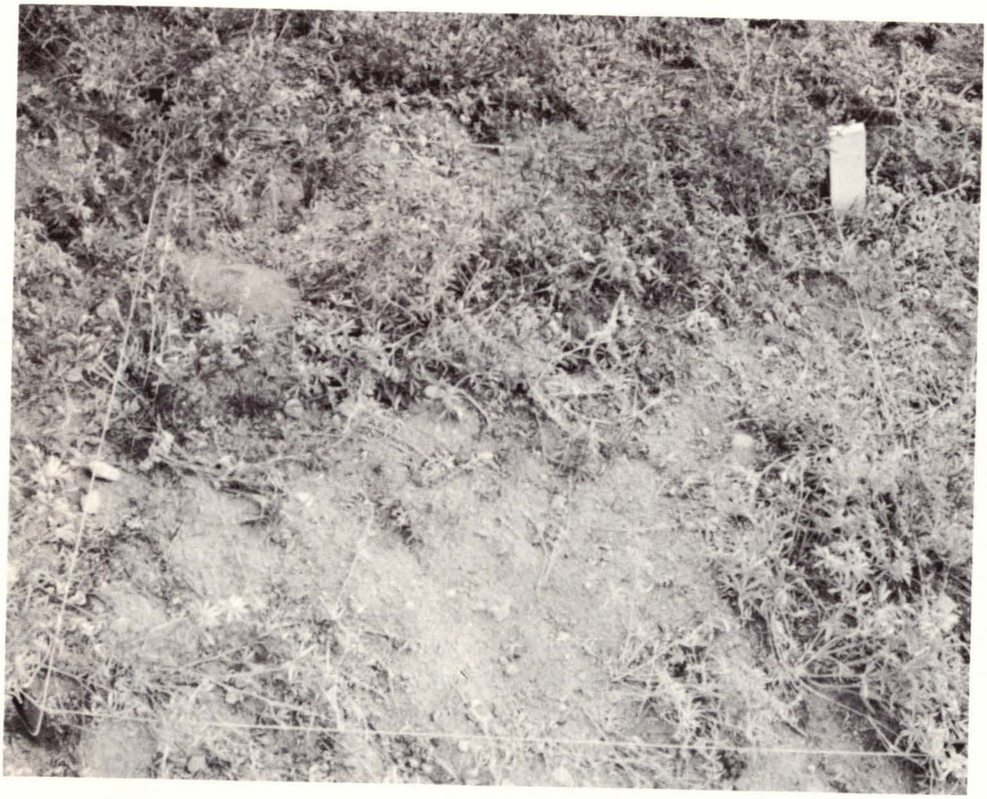
The perennial vegetation is predominantly a mixture of Letterman needlegrass (Stipa lettermani), lupine (Lupinus spp.), and a knotweed (Polygonum phytolaccaefolium). Beardless bluebunch wheatgrass (Agropyron inerme), Bromus marginatus, and two eriogonums (Eriogonum umbellatum and E. flavum) are also important in some areas. Bottlebrush squirreltail (Sitanion hystrix) and oniongrass (Melica bulbosa) occur in small amounts throughout the areas of observation. Annuals are much less important at the high elevations than at low elevation; the most common are E. spergulinum and groundsmoke (Gayophytum spp.). Slopes are generally steep, and soils--derived from granite--are coarse and loose.

The most significant trend revealed by the plot data is one in which the grasses as a group--especially needlegrass and wheatgrass--are losing ground to lupine and knotweed. In 1930 more than four-fifths of the quadrats were dominated by grasses; in 1956 grasses dominated only about half the quadrats. The reason for this trend is apparent when the grazing facts are known. This is overgrazed sheep range, and only some of the less palatable forbs remain. Therefore sheep show a marked preference for the grasses and utilize the forbs only very lightly. The chief damage done to lupine and knotweed appears to result from breaking and trampling.

On a few quadrats grasses and forbs both increased, but the forbs increased much more than the grasses.



Before sheep grazing.

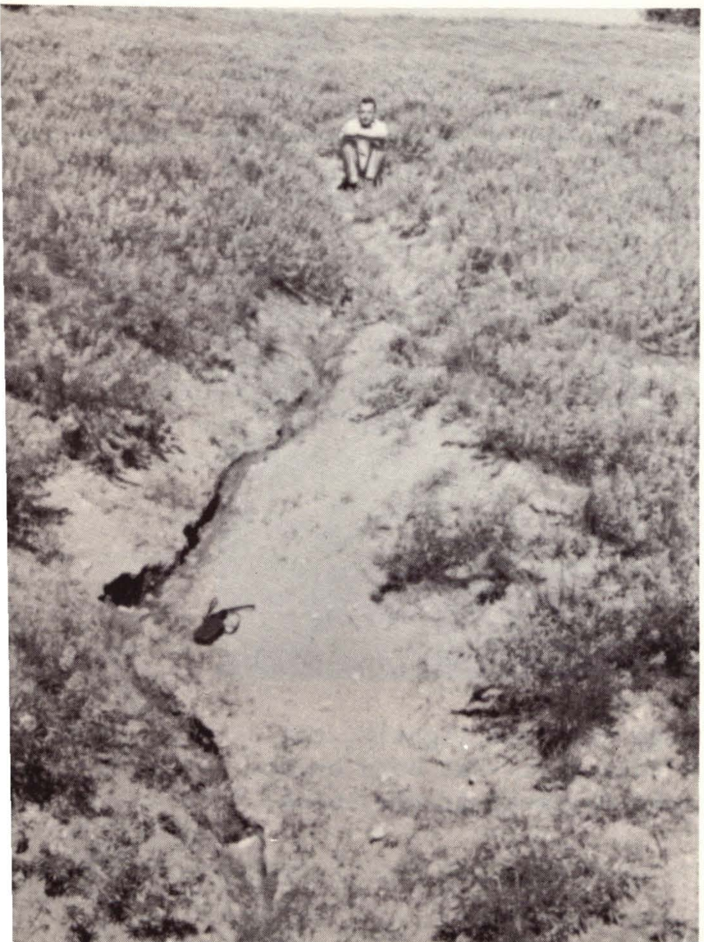


After sheep grazing. Although utilized lightly, the ground cover--mostly lupine on this plot--has been excessively disturbed by trampling and movement of the loose, granitic soil.

The quadrat charts show that many individual plants are at least 25 years old; some were large when they were first charted in 1930. The charts also show that forbs such as lupine and knotweed probably favor the establishment of seedlings of all species by modifying the microenvironment; but it appears that these forbs will eventually crowd the grasses out unless grazing intensity is reduced. No examples of secondary succession under protection from grazing are available. Fenced enclosures erected on all areas when the plots were set out were destroyed by snow.

In general, ground cover of perennial vegetation has increased since 1930. However, the trend is downward because the species largely responsible for the increase in cover are unpalatable forbs. Also, these forbs are less effective than the grasses in holding the soil in place.

Additional evidence of a downward trend is apparent from the status of the gullies that traverse many of the plots. If these gullies are examined after sheep have passed through the area, their appearance is deceiving because, in the loose, coarse soil, the movement of the animals tends to smooth down the sides and round out the bottoms, making them appear inactive. Measurements of gullies made over a span of 25 years show that they are active and are growing in depth at an average rate of approximately 1 cm. per year. Clear evidence of their activity is available if they can be examined soon after a severe storm.



Active gully freshly cut by severe storm of late July 1958. Photo taken 8/1/58. What appears to be good ground cover in background is a mixture of lupine and Stipa which obviously is inadequate to stabilize the site.

Another indication of soil movement that is not associated with drainage channels can be found in the deposition behind the uphill sides of logs lying lengthwise along the contours of the steeper slopes. Such deposits about 5 cm. deep over a period of 20 years were observed. Raindrop splash, gopher activity, and sheep trampling are undoubtedly important contributors to this type of soil movement.

Only one of five study sites appeared to have sufficient ground cover to prevent soil movement. The measured ground cover of living perennial vegetation on this site was 32 percent--the most cover found on the study areas--and litter was estimated to provide an equal or greater amount of cover.

RODENT-RANGE RELATIONS

Since 1952 we have cooperated with the U. S. Fish and Wildlife Service and the Utah Cooperative Wildlife Research Unit in an experimental study of the effects of pocket gophers on high elevation seeded range. For this study two 3-acre plots near Monte Cristo in the Cache National Forest were seeded to a grass mixture including timothy, orchardgrass, tall oatgrass, and smooth brome. On one area gophers were closely controlled; on the other, no control measures were used, and the gopher population was high. Soils on the two areas are similar and seem to have about equal potential productivity.

Gophers undermine grasses and eat the stem bases and root crowns. Note the remains of dead plants along the caved-in tunnel.

Gophers damage range areas in several ways. In the spring they destroy root crowns and stem bases of grasses; this is the most serious type of damage. Their extensive tunneling undermines grass plants and kills many of them. The winter casts, deposited on the ground surface by melting snows, and summer mounds, which cover openings of the tunnels, cover smaller plants and weaken or kill many of them. Winter casts from some types of soil become very hard and partially impervious to water. In the fall, gophers undermine many small plants and pull them into their tunnels for food or nesting material.

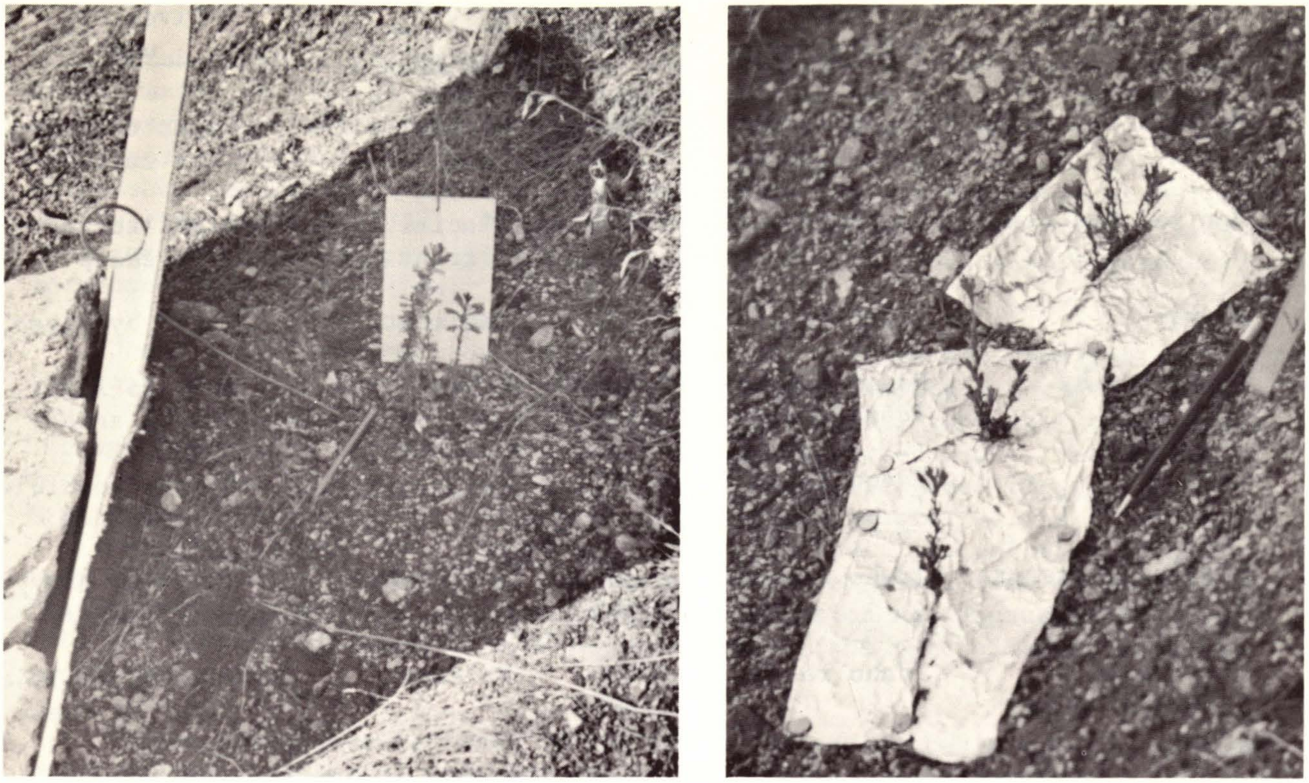
After considering yearly fluctuations of yields due in part to varying weather conditions we have noted a definite downward trend of grass yield on the uncontrolled area in contrast to establishment and maintenance of a full stand on the gopher-controlled area. Annual production of grass from 1952 through 1957 was nearly three times greater on the controlled area. Results of the Monte Cristo studies indicate that for the grass species used, and on range areas similar to those studied in this experiment, some degree of gopher control is essential to maintenance of good seeded grass stands when gopher populations are high.

BIG GAME WINTER RANGE REVEGETATION

Observations during the past two seasons indicate that high soil surface temperatures are responsible for a large amount of first-year seedling mortality of bitterbrush (Purshia tridentata) in southern Idaho.

During the summer of 1958 artificial mulching and shading treatments significantly increased seedling survival on three south-facing sites having granitic soil and an average slope of 64 percent. Survival of shaded, mulched, and control seedlings averaged 67, 66, and 52 percent, respectively. Shade was provided by placing 2-foot cardboard squares so as to shield seedlings from direct sunlight during the hottest part of the day. Mulching consisted of placing 6-inch squares of aluminum foil on the soil surface around each seedling or group of seedlings. Further investigation of this soil-temperature factor is planned.

A test of the value of winter rye (Secale cereale) as a nurse crop for first-year seedlings of bitterbrush showed that this species has no value in increasing seedling survival. The growth form of winter rye on the five test sites was too sparse, and the plants matured too early in the summer to moderate appreciably the microclimate around bitterbrush seedlings. Tests of nine other species are planned, including seven legumes, for use as nurse crops for increasing survival of bitterbrush seeded on depleted game range.



Shading with cardboard (left) and mulching with aluminum foil (right) were equally effective in reducing first-year mortality of bitterbrush seedlings attributed to high temperature of the surface soil.

ECOLOGY OF MOUNTAIN HERBLANDS IN MONTANA

An ecological study of the mountain herblands of western Montana was started last summer. Objectives of the study are to identify and classify the existing plant associations on mountain range areas in various conditions and to correlate them with such site factors as climate, elevation, soil, parent material, topography, fire, and grazing.

After preliminary reconnaissance we selected seven areas for intensive study of the vegetation, soils, and geology. The following tabulation shows the two general plant associations represented in these areas.

Area	Plant association	Elevation	Bedrock or soil parent material	Livestock use
Modesty Cr. Bench	Rough fescue	6,000-7,000	Glacial till	Light to heavy by cattle
Spotted Dog Bench	Rough fescue	7,000	Glacial lacustrine	Light to heavy by sheep
Magpie	Rough fescue	7,300	Sedimentary	Light by sheep
Milwaukee Ry.	Rough fescue-Idaho fescue	5,800	Granite	None to light. Fenced area
Gold Hill	Idaho fescue	5,900	Sedimentary	None. Possible relict area
Vigilante Pasture	Idaho fescue	6,500-7,500	Sedimentary	Light to heavy by cattle
Cliff Lake Natural Area	Idaho fescue	7,000-7,500	Volcanic	None since 1948. Light by sheep

Rough fescue is an important grass on many high elevation ranges in Montana. Since it seems to be highly palatable to livestock, especially horses and cattle, and to elk, it has been virtually eliminated from some ranges. Wherever present, it is being used as a key species to indicate the intensity of grazing. Although rough fescue is not likely to be confused with associated grasses over most of its range in Montana, it could easily be confused with others at the northern and southern limits of its distribution. Studies of specimens in herbaria and in the field show the following characteristics to be reliable and useful for field identification of rough fescue:

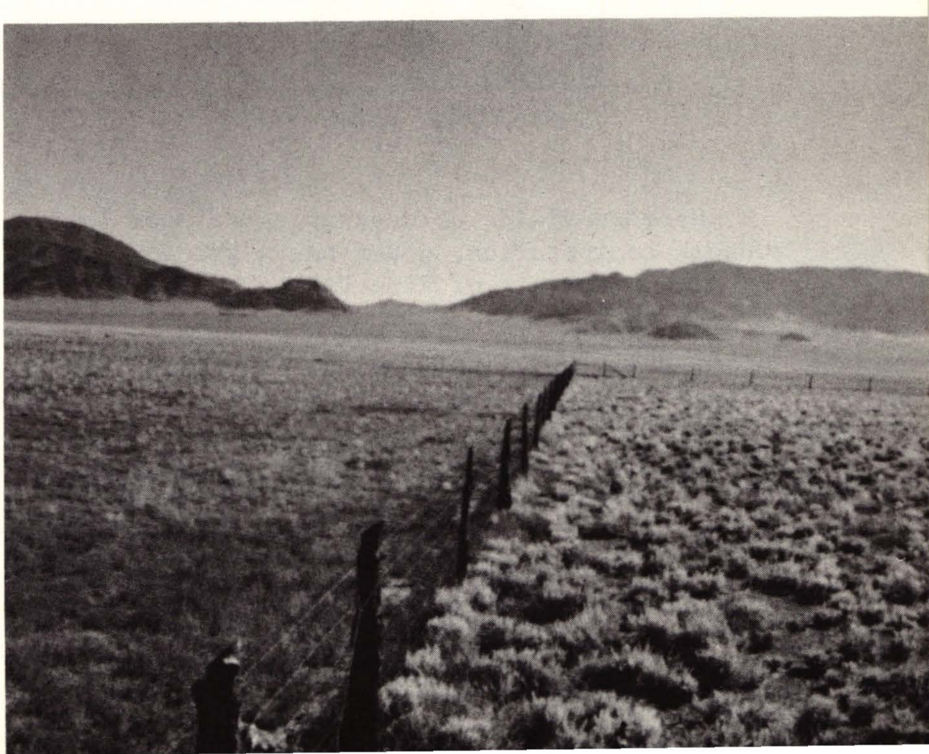
1. Blades involute
2. Sheaths red-violet at base; basal portions persistent
3. Ligule 1 mm. or less
4. Culms erect, densely tufted with nodes; hidden by overlapping sheaths
5. Spikelets borne terminally on the rachii
6. Lemmas 7 to 10 mm. long; awnless or with awn less than 1 mm. long.

DESERT RANGE IMPROVEMENT

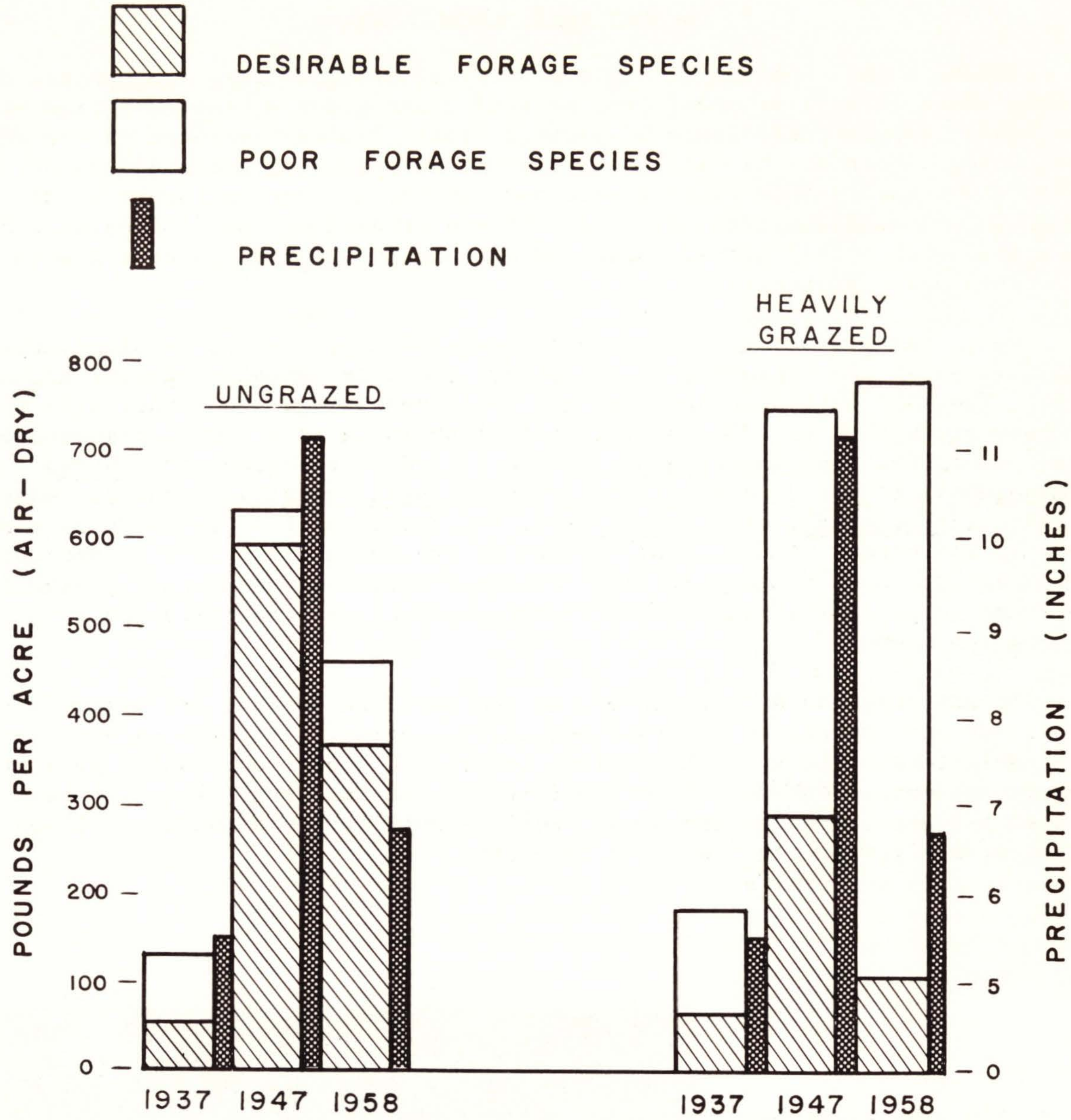
Shrub ranges continue to improve after 20 years of complete protection from grazing as well as under well-managed grazing for a similar period at the Desert Experimental Range in western Utah. Typical response of one important type, winterfat, is illustrated in the accompanying graph and photo, which show results from plots inside and outside a large enclosure established on depleted range in 1937. Although herbage production has fluctuated widely in accord with annual precipitation, desirable forage species have gradually increased under protection.

Under heavy grazing, the yield of desirable species has remained about the same as at the beginning of the study; the less valuable species predominate. The main desirable species, and their percentage contribution to total herbage production in 1958 on protected plots and grazed plots, respectively, were: winterfat (*Eurotia lanata*), 55 and 7; Indian ricegrass (*Oryzopsis hymenoides*), 14 and 3; and galleta grass (*Hilaria jamesii*), 6 and 2. Russian-thistle (*Salsola kali* var. *tenuifolia*), the principal less valuable species, made up 21 percent of the total herbage on protected plots, and 84 percent on the heavily grazed range. Russian-thistle production was unusually high in relation to precipitation in 1958 because most of the precipitation came in spring and summer.

Trends comparable to those on the protected enclosures are being obtained under various systems of moderate and light grazing. Indications are that desirable forage plants will continue to replace poorer ones under good grazing management. However, since precipitation in this area is only 4 to 11 inches per year, changes are slow. Full rehabilitation of badly depleted areas probably will require 30 to 50 years.



A 1958 view of winterfat range overgrazed (left) and ungrazed since 1937. Herbage production in the protected area is 55 percent winterfat, 14 percent Indian ricegrass, and 21 percent Russian-thistle. On the overgrazed range it is only 7 percent winterfat, 3 percent ricegrass, and 84 percent Russian-thistle.



Herbage yields of desirable and poor forage species, in relation to annual precipitation, under heavy grazing and ungrazed since 1937; desert shrub winter range of Pine Valley, western Utah. Yields of Russian-thistle were unusually high in 1958 when most of the scanty precipitation came in spring and summer.

WATERSHED MANAGEMENT RESEARCH

Maintenance of soil stability is the key to good watershed management. Research of this division is pointed towards this in two ways. For stable watersheds, the objective of research is to develop the best management methods and practices possible to keep them undamaged. For damaged or deteriorated watersheds, research seeks to develop the best methods to restore them. Both prevention and restoration measures are aimed at controlling surface runoff, erosion, sedimentation, and floods. Control of these phenomena also facilitates control and improvement in water quality.

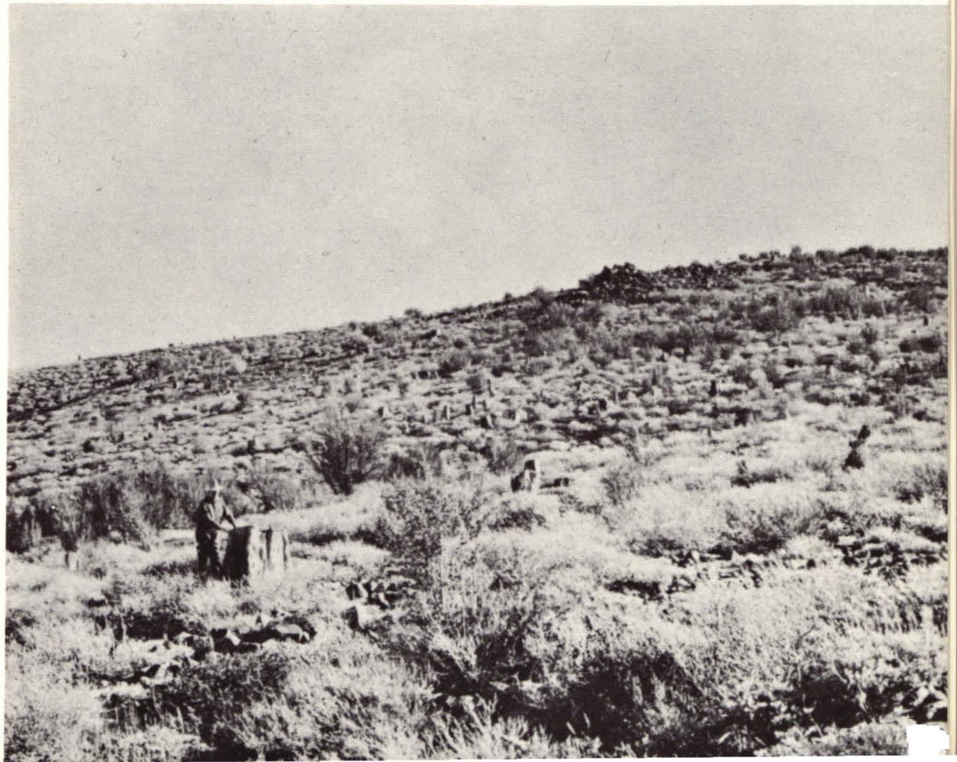
Principal research activities of this division during 1958 in the fields of erosion control and restoration are reported below.

RESTORATION OF DAMAGED WATERSHEDS

East Front of Sierra Nevada Mountains

Winter floods that result from warm temperature and winter rains that melt snowpacks rapidly and saturate soil mantles, and summer floods that are caused by high-intensity storms, have increased in both frequency and violence in recent years on the eastern slopes of the Sierra Nevada. The flood-source areas have been drastically depleted of forest and good range cover by past fires, timber clear cutting during early mining days, and overgrazing.

This flood-source area in the Carson Mountains, Nevada, was once a timbered slope. It was clear cut late in the 1800's and is devoid of forest cover because of fire and lack of any seed source.

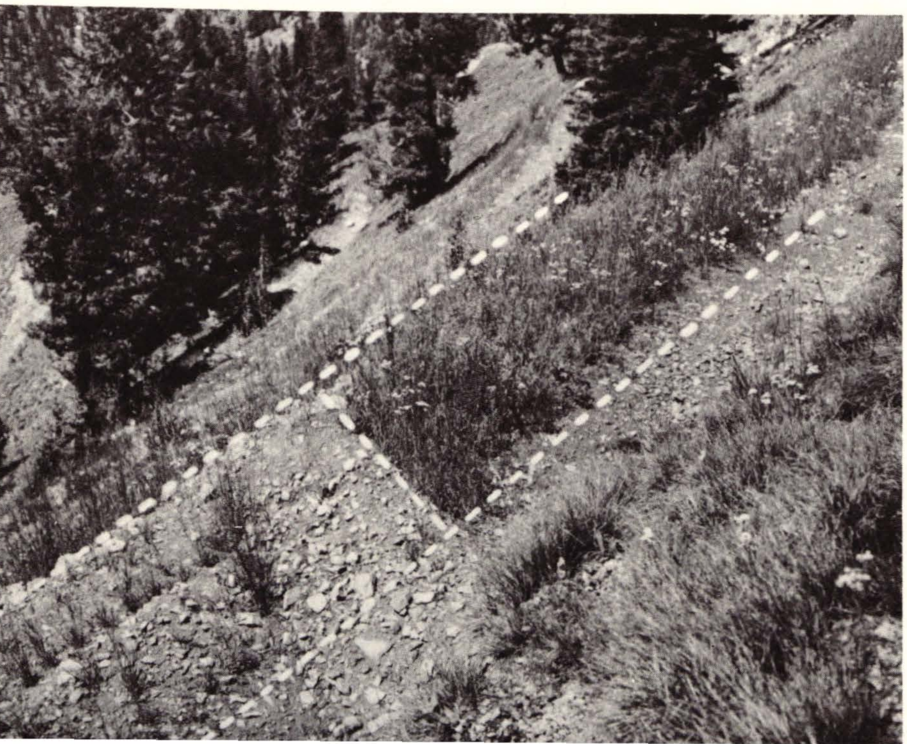


Depletion of vegetation reduces losses by interception and transpiration and thus increases the amount of water available for runoff. But it also markedly reduces protection against the destructive impact of falling rain, increases surface runoff, and accelerates erosion. Physical disturbance aggravates these problems by increasing soil density and decreasing porosity and infiltration. As deterioration worsens, the difficulty of restoring plant cover and regaining hydrologic control of precipitation increases.

To this end, our research program in western Nevada is pointed towards learning how to regain and maintain soil stability on damaged watersheds and thus lessen the flood threat to populated areas and property. The program now being started contains five related phases: (1) inventory of watershed conditions to obtain detailed information about existing resources and their condition; (2) field studies of hydrologic and erosion processes; (3) studies of water management through restoration treatments; (4) evaluation studies of watershed treatments; and (5) helping to implement restoration programs.

Fertilizer Promotes Restoration in Southwestern Idaho

Years of overgrazing, followed by a high-intensity summer storm in 1955, caused a mud-rock flood from Morehead Mountain in southwestern Idaho that almost wiped out a dude ranch in the valley below. Immediately the area was closed to grazing, and in 1956 a watershed restoration program was begun by the Boise National Forest. The damaged watershed was contour trenched and reseeded. At the same time, the Intermountain Station installed an experiment to determine the effectiveness of trenching, reseeding, and fertilizing on the recovery of the damaged range. Study plots to test effects of these treatments were established both on the trenches and the intervening areas between them.



Vegetation on plots established on dikes of contour trenches. Subplot 17 on the left received no fertilizer. Subplot 18 on the right was fertilized with a 46-45-0 mixture.

After two growing seasons, plant cover on the deteriorated intertrench areas shows little improvement. Reseeding and fertilizing without disking these areas have not greatly improved plant cover because competition between old plants and grass seedlings was too severe. On the dikes of contour trenches where soil was disturbed and the old plants destroyed, revegetation was better than on undisturbed areas. Fertilizing and reseeding markedly improved plant cover density and revegetation on the dike of the trenches (see photo). Fertilizers containing nitrogen alone or in combination with phosphorus produced significantly more ground cover of greater height than did applications of phosphorus alone.

The favorable effects of reducing competition between old plants and young seedlings, strongly suggest that some degree and type of soil treatment as seedbed preparation is essential for successful reseeding.

Evaluation Study in Central Utah

Pleasant Creek watershed in central Utah was one of the first drainage areas treated under provisions of the Small Watershed Demonstration project of the Agricultural Appropriations Act of F. Y. 1954. In 1955, under technical supervision of this station, the initial study of existing conditions prior to application of restoration treatments was made on portions of this area. A followup evaluation study in the summer of 1958, 3 years after restoration, consisted of reexamination of transects, infiltrometer plots, erosion plots, and channel sections established before treatment.

Data gathered during the reexamination are now being analyzed. A few observations and results can be reported at this time. The restoration treatment of trenching, disking, and seeding has been effective in controlling surface runoff and erosion from the watershed. A significant improvement in live plant cover has been achieved. Improvement in the proportion of grasses is very marked. The amount of surface litter was reduced when it was disked into the soil, but this reduction should be only temporary. Litter is expected to accumulate rapidly as restoration progresses.

IMPROVEMENT OF WATER QUALITY

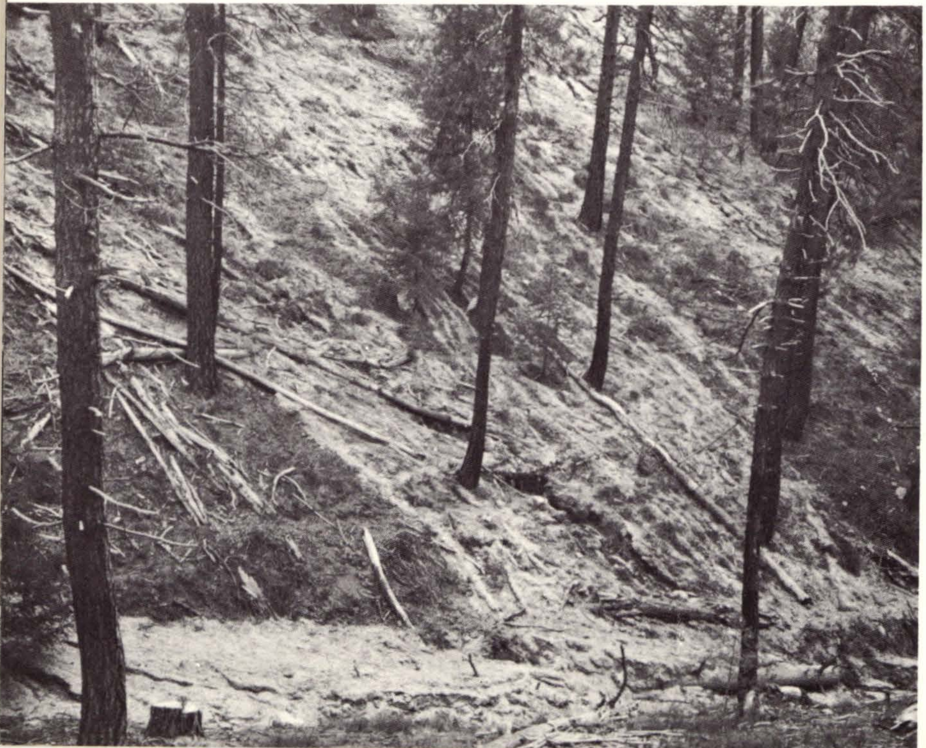
Control of Sediment from Logging Roads

A critical problem on operated timberlands in our area is that of keeping road sediment from reaching and damaging stream channels after logging (see photo). A new approach toward solving this problem is based on the idea of predetermining: (1) the width of protective strips to be left between new logging roads, and (2) the treatment to be applied to the road and protective strip to confine road sediment to these areas. In 1958 we made progress in developing a method based on a prediction equation that can be used by road locators to accomplish control of sediment from newly built roads. The equation relates several variables of road and slope to the distance sediment moves downslope from road surfaces and fills.

Application of this road location guide is not difficult. To prevent positioning too much of a new logging road too close to a drainage or lower road, the locator determines the expected distance of sediment flow under a set of given conditions. Because some of the road and slope variables, e.g., road gradient and cross ditch interval, can be adjusted, the road locator refers to charts or tables derived from the equation and selects that combination of variables affording the desired degree of protection against sediment flow. He can use logging debris effectively to increase the number of obstructions on the lower slope to retard the flow of sediment.

Following logging operations, the road location method can provide safeguards against further production of road sediment. The number of cross ditches and the intensity of slope obstructions can be increased systematically in accord with expected sediment flow from critical road sections.

This road location guide, with appropriate tables, charts, and examples of their use, will be published soon by the station.



Excessive sediment derived from fill material and deposited in an ephemeral stream channel on the Little Owl Creek watershed in southwestern Idaho.

Northern Region Road Location Studies

The average volume of water yielded annually as streamflow from forest lands of Region 1 equals a volume 18 inches in depth over the entire forested area. Reduction of infiltration capacity by road construction disturbance and lowered precipitation interception following the removal of timber will increase the amount of additional water that must be disposed of from these sites by as much as 9 to 15 inches annually. Such great increases can create highly dangerous potentials for erosion and sediment production unless proper control and regulation of runoff are obtained.

Efforts have been made to locate and construct logging roads on national forests so as to provide adequate control of runoff and sediment. Guides previously developed have lacked means for specifically evaluating the various watershed characteristics that affect erosion and sediment movement and the relationships between them. For this reason, it has been difficult at times to determine to what extent proposed road locations and designs would create rather than prevent undesirable erosion problems.

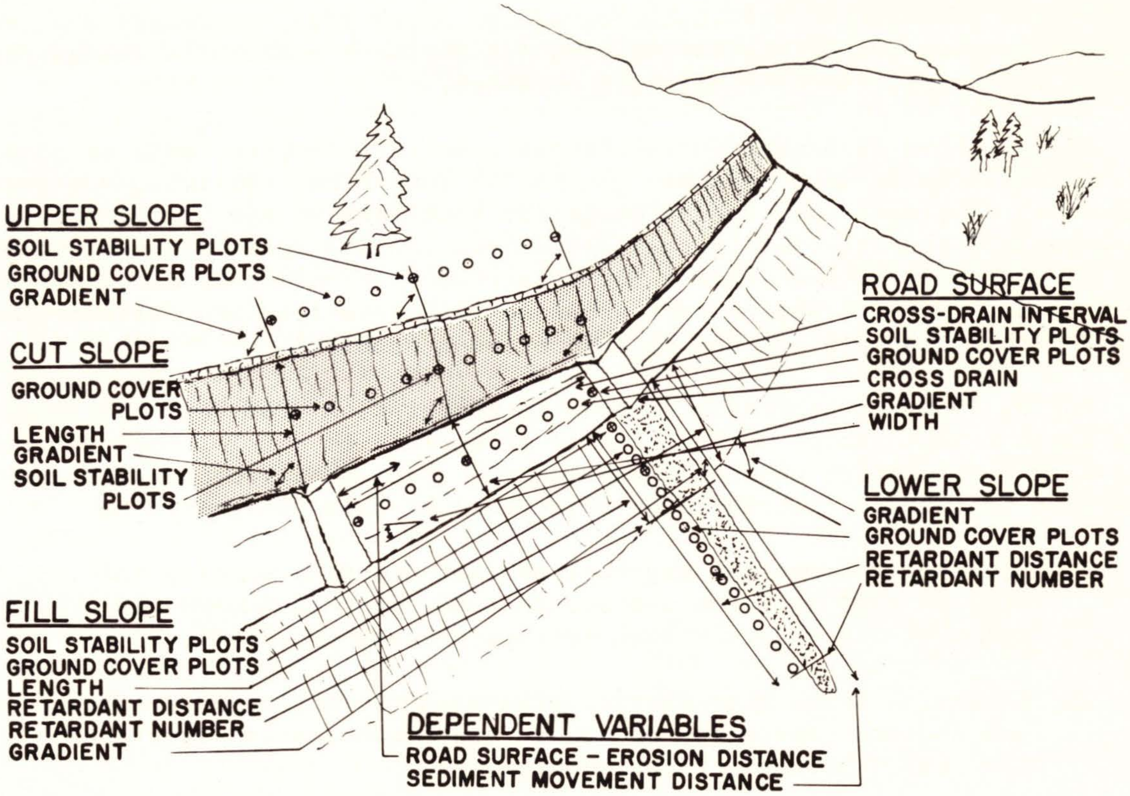
During 1958, we started a study with cooperation from Region 1 to determine these relationships on major soils groups and to develop the criteria necessary for locating and designing logging roads that provide acceptable watershed protection. Three major objectives of this study were to:

1. Develop mathematical expressions that describe erosive cutting on road surfaces and sediment movement from roads in terms of site factors that influence these processes.

2. Determine which site factors significantly influence erosion and sediment movement, and to develop quantitative equations that describe these relationships.

3. Develop from these equations the criteria for road location and design that are necessary to prevent water from cutting into and eroding road surfaces and keeping sediment from reaching streams, adjacent roads, or other areas critical in maintaining high quality streamflow.

We achieved the first of these objectives in the spring of 1958 with the development of equations expressing the theoretical relationships of 22 measurable watershed characteristics to erosive cutting of road surfaces and distance of sediment movement downslope from roads. The kind of watershed variables studied and their location with respect to a road are shown schematically in the diagram below.


UPPER SLOPE
SOIL STABILITY PLOTS
GROUND COVER PLOTS
GRADIENT
CUT SLOPE
GROUND COVER PLOTS
LENGTH
GRADIENT
SOIL STABILITY PLOTS
FILL SLOPE
SOIL STABILITY PLOTS
GROUND COVER PLOTS
LENGTH
RETARDANT DISTANCE
RETARDANT NUMBER
GRADIENT
ROAD SURFACE
CROSS-DRAIN INTERVAL
SOIL STABILITY PLOTS
GROUND COVER PLOTS
CROSS DRAIN
GRADIENT
WIDTH
LOWER SLOPE
GRADIENT
GROUND COVER PLOTS
RETARDANT DISTANCE
RETARDANT NUMBER
DEPENDENT VARIABLES
ROAD SURFACE - EROSION DISTANCE
SEDIMENT MOVEMENT DISTANCE

Location of crossdrains on a logging road, showing the kind and location of factors studied.

During the summer and fall of 1958 we measured these 22 independent and 2 dependent watershed characteristics on soils derived from 5 groups of materials: loess, granite, sedimentary rocks, basalt, and glacial silt. We recorded from 75 to 100 individual measurements on each of 600 study sites on logging roads in national forest timber sale areas. One segment of the study is concerned with the effects of road construction disturbance on the aggregate stability of the soil. The Forestry School at Montana State University is cooperating in making the mechanical and aggregate analyses of the surface soil from upper slope, cut, road surface, and fill sections of the study sites.

Because of the large number of data involved, this study was designed for analysis by electronic digital computer. Although this analysis is not yet complete, preliminary examination of summarized data tentatively indicates some of the more obvious important relationships:

1. Loess and glacial silt soils of the five soil groups studied, eroded most on road surfaces and produced the longest sediment flows below roads.
2. Of all soils considered, fill sections appear to be the outstanding source of sediment.
3. Within each soil group, the variables of road gradient and of combined road width and cut slope height appear to exert most influence on the distance water flows down a road surface before it begins to cut into the surface.
4. The number, location, and frequency of obstacles reduces sediment flow over any type of soil.

PUBLICATIONS

A. Departmental publications

BLAISDELL, JAMES P. Seasonal development and yield of native plants on the Upper Snake River Plains and their relation to certain climatic factors. U. S. Dept. Agr. Tech. Bul. 1190, 68 pp., illus.

This study of the sagebrush-grass-forb (weed) vegetation at the U. S. Sheep Experiment Station near Dubois, Idaho, is based on data over the 23-year period 1932-54. Reports on how and when plants grow, their seasonal and yearly variations, the effects of climate on various classes of plants. Suggests methods for estimating the opening date for grazing and the yields to be expected.

HUTCHINGS, SELAR S. Hauling water to sheep on western ranges. U. S. Dept. Agr. Leaflet 423, 8 pp., illus.

Explains the need for hauling water to sheep on western ranges. Discusses methods and equipment to use, amount of water needed, cost of hauling water, and benefits derived.

HUTCHISON, S. BLAIR, and LEONARD I. BARRETT. Timber resources for America's future, (Timber supply outlook). U. S. Dept. Agr., Forest Service, Forest Resource Report 14, 475-496, illus.

This section of Timber Resources for America's Future analyzes the capacity of forests in the United States to meet different levels of timber demand in the years 1975 and 2000 if forestry continues to improve at its present rate.

B. Publications in scientific and professional journals, etc.

BAILEY, REED W. Living in harmony with nature. Utah Ed. Rev. 51(5): 10-11, 37-39, illus.

Discusses conservation broadly in relation to rapidly increasing world population, and urges inclusion of conservation in regular school courses of study.

BARROWS, J. S. The challenge of fire research in western forestry. Colorado Forester, 1958 edition. (No reprints available.)

Summarizes the present status of basic forest fire research in the West. Fire research efforts will be directed toward aerial attack, lightning fires, hazard reduction, prescribed fire, fire weather, fire planning, and the relatively unknown aspects of the combustion process.

BARROWS, J. S. They probe lightning fires. West. Conserv. Jour. 15(1): 20-21, 42-43, illus. (No reprints available.)

Describes program of cooperative research on the problem of lightning-caused fires (Project Skyfire) now being carried on in several northwestern states; summarizes results of this research to date.

COPELAND, OTIS L., JR. Soil-site index studies of western white pine in the northern Rocky Mountain region. Soil Sci. Soc. Amer. Proc. 22: 268-269.

Reports relationships of certain physical soil properties to site index (at age 50) of western white pine. Discusses applications of these relationships in forest management.

CURTIS, JAMES D., and ALVIN K. WILSON. A test of group selection in Idaho ponderosa pine. Jour. Forestry 56: 182-189, illus.

Explains reasons for and steps in cutting old-growth ponderosa pine forests by the group selection method. Explains the means by which area and volume are employed in group selection, and outlines two procedures for applying the method on a large scale.

DIVISION OF FOREST FIRE RESEARCH. Man pits himself against Nature. Timberman 59: 34-36+, illus.

Gives detailed information about Forest Service research studies (Project Skyfire) on lightning storms, their origin, behavior, and possibilities for suppressing them by cloud seeding.

ELLISON, LINCOLN, and WALTER R. HOUSTON. Production of herbaceous vegetation in openings and under canopies of western aspen. Ecology 39: 337-345, illus.

Contrary to the usual condition on Intermountain ranges, forage production in openings is potentially greater than under aspen. Competition from aspen roots limits herbage production under trees, but differential grazing evidently is a greater limiting factor in openings. Discusses implications to grazing management.

GRAHAM, DONALD P. Results of some silvicultural tests in pole blight diseased white pine stands. Jour. Forestry 56: 284-287.

Thinning subsequent to the appearance of pole blight and salvage cutting of affected areas do not reduce progress of the disease in the residual stands.

GRAHAM, DONALD P. Results of pole blight damage surveys in the western white pine type. Jour. Forestry 56: 652-655, illus.

Results on sample plots throughout the known range of pole blight show that the extent of damage varies with the length of time the disease has been present in the sampled areas.

JOHNSON, PHILIP C. Pests attack inland timber. West. Conserv. Jour. 15(1): 12, 56-57, illus. (No reprints available.)

Reviews status of forest insect conditions during 1957 in northeastern Washington, northern Idaho, Montana, northwestern South Dakota, and northeastern Wyoming.

JOHNSON, PHILIP C. The forest entomologist--forester or entomologist? Jour. Econ. Ent. 51: 264-265, (editorial).

Discusses the position of the forest entomologist during development of forest entomology from the end of the 19th century. Stresses the need for more specialized training for today's forest entomologist.

JULANDER, ODELL. Techniques in studying competition between big game and livestock. Jour. Range Mangt. 11: 18-21, illus.

Describes techniques used in determining forage preferences and range use by deer and cattle and deer and sheep on ranges used by deer in winter and livestock in spring and fall, and on summer ranges used simultaneously by deer and livestock.

KIMMEY, JAMES W. White pine blister rust in western United States. Fifth West. Internatl. Forest Disease Work Conf. Proc., pp. 75-81. (No reprints available.)

The rust has greatly reduced the acreage of timber stands managed for the white pines, because management is more intense and more costly. Only by correlating blister rust control and forest management practices can white pines be grown on sound economic basis.

KOTOK, E. S. Utilization will rely upon new species. West. Conserv. Jour. 15(1): 22, illus. (No reprints available.)

Considerable progress is being made in improving the utilization of the timber crop, especially as a result of such new outlets for fiber as the pulp mill near Missoula, Montana.

LEAPHART, CHARLES D. Pole blight--how it may influence western white pine management in light of current knowledge. Jour. Forestry 56: 746-751. (Also published in the Fifth West. Internatl. Forest Disease Work Conf. Proc., pp. 51-62.)

A complete analysis of what is known about pole blight is made in regard to the disease's potential influence on future white pine management. Presents risk classification of white pine sites based on soil moisture conditions.

MARSTON, RICHARD B. Parrish Canyon, Utah: a lesson in flood sources. Jour. Soil and Water Conserv. 13: 165-167, illus.

On steep slopes in this region an extremely delicate balance exists between climate, vegetation, and soil. Discusses effects of watershed deterioration as a cause of destructive floods.

MIELKE, JAMES L. Forest pathology education: in-Service training. Fifth West. Internatl. Forest Disease Work Conf. Proc., pp. 95-98. (No reprints available.)

Discusses the need of in-Service training of foresters in tree diseases.

MOESSNER, KARL E. Bring the forest to your desk. Ames Forester 45: 16-21.

This semipopular article briefly summarizes the forester's present position in photogrammetry; enumerates some immediate problems he faces in using this valuable tool.

MOESSNER, KARL E. Graphic control charts--a possible aid to photogrammetric training. Photogrammetric Engin. 24: 643-650, illus.

Discusses use of control and progress charts in evaluating skill level and progress of trainees. Charts discussed are based on problems in determining scale, measuring angles, and measuring tree height by parallax.

MUEGGLER, WALTER F., and JAMES P. BLAISDELL. Effects on associated species of burning, rotobeating, spraying, and railing sagebrush. Jour. Range Mangt. 11: 61-66, illus.

All four treatments greatly reduced sagebrush and increased available forage. Burning and rotobeating were most effective, but burning was generally injurious to grasses and spraying injured forbs.

PACKER, PAUL E. Management of forest watersheds and improvement of fish habitat. Amer. Fisheries Soc. Trans. 87: 392-397.

Discusses some important hydrologic processes that operate on watersheds. Emphasizes the principal kinds of watershed protection and methods of forest management for better regulated and higher quality streamflow in relation to maintenance of desirable fish habitat.

ROBINETTE, W. LESLIE, ROBERT B. FERGUSON, and JAY S. GASHWILER. Problems involved in the use of deer pellet group counts. 23rd No. Amer. Wildlife Conf. Trans., pp. 411-425, illus.

Discusses methods for sampling deer pellet groups for census and trend in herd numbers. Explains problems involved and makes suggestions on intensity of sampling, size of plots, and other factors.

ROGERS, GLENN, ODELL JULANDER, and W. LESLIE ROBINETTE. Pellet-group counts for deer census and range-use index. Jour. Wildlife Mangt. 22: 193-199.

Reports the deer pellet-group studies made within Colorado State Game and Fish Department deer pastures at Little Hills Experiment Station, Colorado. Discusses application of the pellet-group method for deer census and range-use index and factors affecting use of this method.

SQUILLACE, A. E., and R. T. BINGHAM. Localized ecotypic variation in western white pine. Forest Sci. 4: 20-34, illus.

Study of juvenile growth rates, apparent seed osmotic pressures, and foliage dry matter content of both controlled- and wind-pollinated seed and seedling progenies of Pinus monticola Dougl. trees growing on radically different sites indicated existence of ecotypes of very local nature.

SQUILLACE, A. E., and R. T. BINGHAM. Selective fertilization in Pinus monticola Dougl. I. Preliminary results. Silvae Genetica 7, Heft 6: 188-196, illus.

Describes the preliminary results, based on 1-year-old progenies, from three tests to determine the selective fertilization effects of competing pollen in Pinus monticola Dougl.; makes recommendations for future study.

STAGE, A. R. An aid for comparing variable plot radius with fixed plot radius cruise designs. Jour. Forestry 56: 593, illus.

Presents a diagram expressing the relation of plot size to tree size for point sampling. Shows that point sampling is simply an extension of the practice of using samples derived from several concentric plots.

STAGE, A. R. Growth of thinned ponderosa pine in western Montana. Jour. Forestry 56: 757-760, illus.

Describes effects of thinning dense young stands of ponderosa pine in western Montana. Compares growth on stands at several intensities of thinning with growth on unthinned plots.

WIKSTROM, JOHN H. Market outlook for lodgepole pine. Jour. Forestry 56: 643-646.

Because of its relatively small size, lodgepole pine has been marketed heavily for poles, piling, and pulp. Article shows need for developing cheaper methods for handling small trees and new ways to use narrow boards so as to improve the market position of lodgepole.

C. Processed reports

BOE, KENNETH N. Silvics of western larch. Misc. Pub. 16, 20 pp., illus.

Describes habitat conditions, life history, races, and reaction to management.

CURTIS, JAMES D. Germinative capacity of Engelmann spruce seed. Research Note 58, 3 pp.

Germinative capacities of Engelmann spruce seed from eight national forests in the Intermountain region tested over a 3-year period are listed with brief comments on the values obtained from the tests.

CURTIS, JAMES D. Town Creek plantations, Centerville, Idaho. Brochure. 4 pp., illus.

This visitors' guide to the Town Creek plantations describes the location and layout of a 5-year, 450-acre planting experiment started in 1954. Describes three kinds of stock, the three types of site preparation, and the means of identifying them at the plantations.

DENTON, ROBERT E. The larch casebearer in Idaho--a new defoliator record for western forests. Research Note 51, 6 pp., illus.

Reports the finding of the casebearer in western larch for the first time around St. Maries, Idaho, where considerable defoliation occurred in 1957.

DIVISION OF FOREST FIRE RESEARCH. Electric fan psychrometer. Tech. Equip. Rpt. No. F-1, 6 pp., illus. (No reprints available.)

Describes the development of a small battery-powered motor and fan unit to be used in aspirating the thermometer tubes of a psychrometer used chiefly for fire-danger rating.

DIVISION OF FOREST FIRE RESEARCH. Totalizing wind counter for contacting-type anemometers. Tech. Equip. Rpt. No. F-2, 6 pp., illus. (No reprints available.)

Describes the development of a wind counter for fire-danger rating use that will not cause excessive battery drain if the anemometer comes to rest on contact, nor cause spurious count due to contact chatter.

DIVISION OF FOREST INSECT RESEARCH. Forest insect conditions in the Intermountain and northern Rocky Mountain States during 1957. Misc. Pub. 13, 11 pp., illus.

Reviews the status of numerous forest insect pests during 1957, including major species as well as those of lesser economic importance.

JOHNSON, PHILIP C. Spruce spider mite infestations in Douglas-fir forests. Research Paper 55, 14 pp., illus.

Reports unusually heavy populations of spruce spider mites in Montana on Douglas-fir following spraying projects to control spruce budworm in Montana.

KOTOK, E. S. Weather records as guides to air-drying lumber. Research Note 56, 3 pp., illus.

Relates average temperature and humidity for a 5-year period at eight selected cities in the Intermountain region to the feasibility of air-drying lumber.

LEAPHART, CHARLES D. Root characteristics of western white pine and associated tree species in a stand affected with pole blight of white pine. Research Paper 52, 11 pp., illus.

The length of rootlet per unit of structural root is quite low in white pine in comparison to other species. Other root characteristics also make white pine more susceptible to drought damage than any of its associated tree species.

LYNCH, DONALD W. Diameter growth of young ponderosa pine trees in the Inland Empire. Research Note 59, 3 pp., illus.

Presents tables of predicted 10-year diameter growth by age and d.b.h. for three broad site classes. Describes use of these tables and the classification of stands into the broad site classes.

LYNCH, DONALD W. Effects of stocking on site measurement and yield of second-growth ponderosa pine in the Inland Empire. Research Paper 56, 39 pp., illus.

Dense stocking of young ponderosa pine stands reduces growth on poor sites and introduces errors in site determination by the usual method. This paper provides revised site curves and presents a cubic-foot and board-foot growth prediction method that includes changes in stocking with age.

MARSTON, R. B. The Davis County Experimental Watershed story. Brochure. 39 pp., illus.

This guide sketches the history of devastating floods in this area; explains the success and significance of restoration of damaged watersheds in preventing floods; describes the research program aimed at determining how watersheds function.

MOESSNER, KARL E. Stereograms in ponderosa pine. Research Note 60, 3 pp., illus.

Lists a new series of 39 aerial and ground stereograms illustrating ponderosa pine stands in Idaho, Colorado, and South Dakota. Stereograms include measurements and brief descriptions of stand site and soil conditions.

ROE, ARTHUR L. Silvics of black cottonwood. Misc. Pub. 17, 21 pp., illus.

Describes habitat conditions, life history, races, hybrids, and reaction to management.

SHEARER, RAYMOND C., and JAMES L. MIELKE. An annotated list of the diseases of western larch. Research Note 53, 6 pp.

Contains information only on the dwarfmistletoe and those fungi reported to cause disease. Very little is now known about the pathology of western larch.

WILSON, ALVIN K. Idaho lumber production, 1956. Forest Survey Release 1, 9 pp.

A statistical analysis of Idaho's record lumber cut, showing volume of cut by species, county of origin, and size of mill.

WILSON, ALVIN K. Montana lumber production, 1956. Forest Survey Release 2, 8 pp.

A statistical analysis of Montana's all-time high lumber cut, showing volume of cut by species, county of origin, and size of mill.

WILSON, ALVIN K. Montana Christmas tree shipments decline in 1957. Research Note 52, 4 pp.

Montana shipped more than 3.7 million Christmas trees in 1957. For the first time on record, more than 1 million were shipped by truck; rail shipments declined, in percentage, to the lowest point on record.

WILSON, ALVIN K. Log production in Idaho and Montana, 1956. Research Note 54, 7 pp.

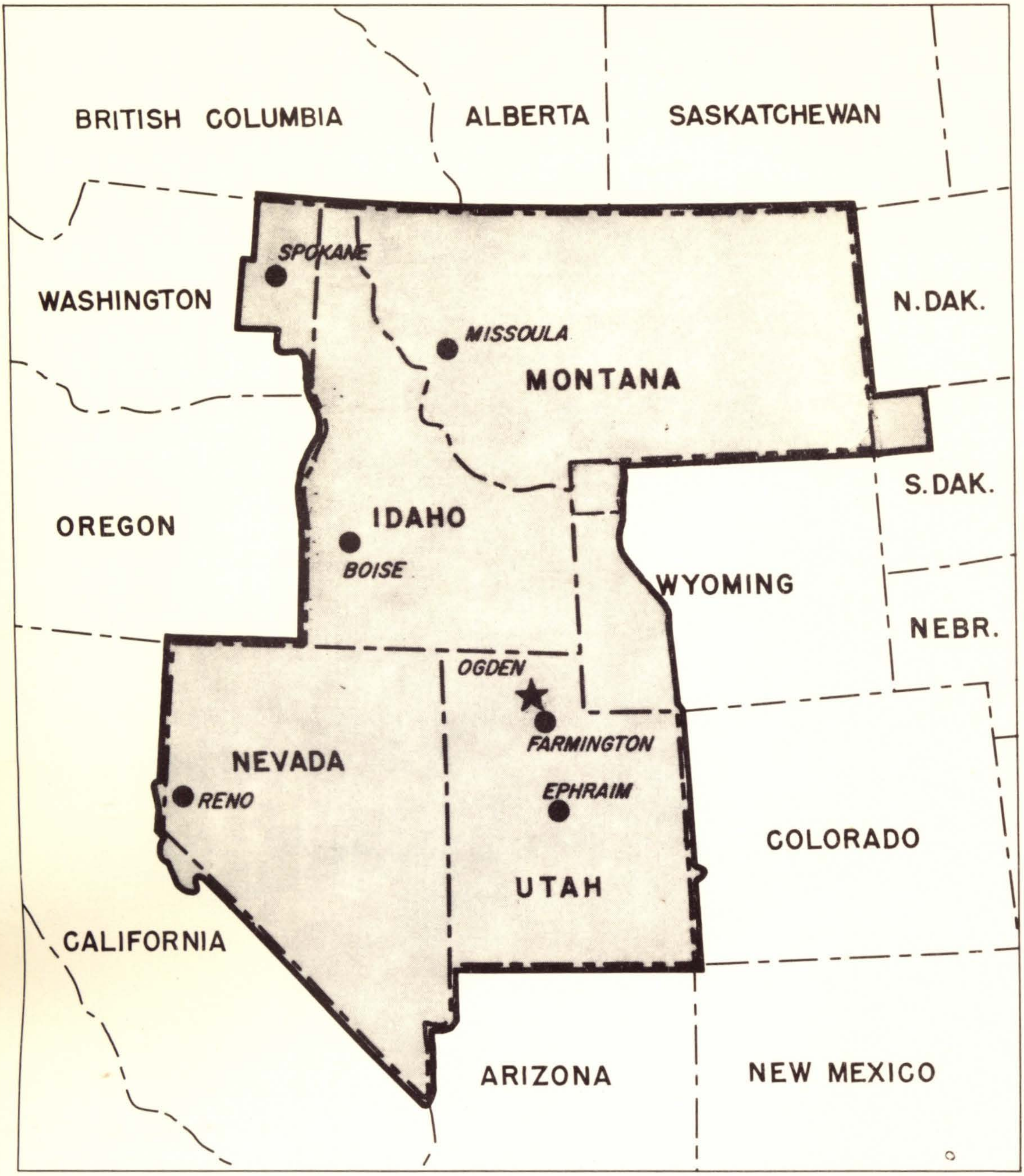
Presents the results of a survey of the volumes of saw logs (for lumber) and veneer logs cut from Idaho and Montana timberlands in 1956 by state, subunits, counties, and species. Douglas-fir was the leading species in Idaho; in Montana the spruce salvage project made Engelmann spruce the leading species.

WILSON, ALVIN K. Pulpwood production in Idaho and Montana, 1956. Research Note 55, 3 pp.

Pulpwood production in the Idaho-Montana-eastern Washington area increased 2-1/2 times from 1954 to 1956. Increase is attributed to expanded capacity of pulp mills in the area plus increased shipment to mills in the Great Lakes region.

WILSON, ALVIN K. Production of poles in Montana, Idaho, and northeastern Washington, 1957. Research Note 57, 5 pp.

Annual survey of pole production in 1957 showed a moderate decline from the 1956 volume; even so, production was third best since 1947. Western redcedar was the favored species.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